SCIENCE ABSTRACTS.

Section A.—PHYSICS.

APRIL 1909.

GENERAL PHYSICS.

590. 10,000,000-*lb. Testing Machine.* **R. L. Humphrey.** (Eng. News, 61. p. 166, Feb. 11, 1909. Eng. Record, 59. p. 164, Feb. 6, 1909.)—This is a vertical hydraulic press which will take columns up to 65 ft. long and about 6 ft. square. The load is weighed with a contract accuracy of $\frac{1}{3}$ per cent. for loads over 100,000 lbs. by weighing with the ordinary multiple lever arrangement the pressure on a piston of $\frac{1}{80}$ of the area of the main cylinder, and connected with it. Oil pressure is applied by a triple-plunger pump with a 15-h.p. motor, which when operated at its slowest speed supplies sufficient oil through a needle valve to compensate for any leakage. The main ram has a movement of 24 in. at speeds of from $\frac{1}{80}$ to $\frac{1}{2}$ in. per min. The machine is being made by Olsen for the Structural Materials Testing Laboratories of the U.S. Geological Survey. F. R.

591. *Registration of Absolute Seismic Movements.* **G. Lippmann.** (Comptes Rendus, 148. pp. 138–140, Jan. 18, 1909.)—The author proposes to measure the absolute acceleration of ground movements during seismic disturbances by employing a special form of galvanometric record with the seismograph pendulum. A small lens is attached to the pendulum, which forms an image of a luminous point from a galvanometer thread on a strip of sensitive paper. C. P. B.

592. *Compressibilities of the Elements and their Periodic Relations.* **T. W. Richards, W. N. Stull, F. N. Brink, and F. Bonnet, Jr.** (Amer. Chem. Soc., Journ. 31. pp. 154–158, Feb., 1909.)—It has been shown previously [Abstracts Nos. 1173, 1174, 1211 (1908)] that, in some cases at least, atomic volume is probably in part dependent on the intensity of the affinities concerned in holding the material together. The authors give a table showing the compressibilities of a number of elements as determined in relation to the compressibility of mercury. The curve connecting atomic weights and compressibilities of the elements is very similar to Lothar Meyer's atomic volume curve. The compressibilities and atomic volumes are, in many

cases, more or less parallel properties, but this parallelism seems to hold, even approximately, only between similar elements. Thus with Mg, Ca, Zn, Cd, and Hg the compressibilities and atomic volumes are in parallel sequence, as is also the case with the alkali metals. Tin and lead exhibit a similar relation, but with the less compressible elements possessing very high boiling-points, this parallelism seems to cease. In many cases the coefficients of expansion are also parallel with the compressibilities, especially in those cases where the atomic volumes are nearly identical, but the relation between these two quantities is not that demanded by Dupré's empirical rule—

$$\beta' = \beta a'\Delta^2 T'/a\Delta'^2 T.$$

T. H. P.

593. *Compressibilities of the Chlorides, Bromides, and Iodides of Sodium, Potassium, Silver, and Thallium.* **T. W. Richards** and **G. Jones.** (Amer. Chem. Soc., Journ. 31. pp. 158–191, Feb., 1909.)—The compressibilities of these twelve salts between 100 and 500 megabars (megadynes/cm.^{2}) are as follows: NaCl, 0·0000041; NaBr, 0·0000051; NaI, 0·0000069; KCl, 0·0000050; KBr, 0·0000062; KI, 0·0000086; AgCl, 0·0000022; AgBr, 0·0000026; AgI, 0·0000039; TlCl, 0·0000047; TlBr, 0·0000051; Tl I, 0·0000067. Comparison of these values with the volatility, surface tension, internal stress and heat of formation of the salts, and with the compressibility of the elements and the contraction which occurs during the formation of the salts from their elements, gives evidence in support of the hypothesis that the volumes of liquids and solids are essentially dependent on the chemical and cohesive affinities existing within them, and also confirms the significance of changing atomic volume. T. H. P.

594. *Cold Working and Tensile Strength of Copper and Brass.* **R. Stribeck.** (Zeitschr. Vereines Deutsch. Ing. 53. pp. 241–250, Feb. 13, 1909.)—Cold rolling and drawing are represented graphically as follows: With percentage reduction in drawing, since previous annealing, as abscissæ, and area of bar as ordinates, a straight line inclined at 45° to the axes is obtained, which cuts off equal segments from each axis. If tensile tests be made after various amounts of reduction (without intermediate annealing), the area of section, F_e, at the moment of commencement of local contraction, it was expected, would follow a straight-line law parallel to the axis of reductions until the 45° line is met, in a test piece which has had a reduction of e per cent., and then fall very slightly below the 45° line but parallel to it. Contracted area of fracture would follow a straight-line law similarly as far as e per cent., and then grade off by a curve into the 45° line. The results of tensile tests of round copper and brass (Cu 72, Zn 28 per cent.) bars annealed at 700° C. and drawn, and of brass plate annealed at 700° or 400° and rolled, are given in detail, and bear out the above theory closely, with the single discrepancy that there is a marked hump before reaching e on the curve of F_e. The Brinell hardness-number for the brass plate annealed at 700° or 400° was found to be $H = 47 + 2{\cdot}1\sigma_{s,e}$, where $\sigma_{s,e}$ is the yield-point, or, in case of doubt, the stress at the beginning of local contraction. F. R.

595. *Hardness of Metals and Temperature.* **A. Kürth.** (Zeitschr. Vereines Deutsch. Ing. 53. pp. 85–92, Jan. 16, and pp. 209–216, Feb. 6, 1909.)—It is found that for copper, silver, and tin the relation between hardness (Brinell method) and temperature is linear, provided time be allowed for the metal to anneal itself at the test temperature. The hardness of zinc falls at a decreasing rate as the temperature increases. For aluminium the curve is slightly different from a straight line, and the hardness of nickel decreases at an accelerating rate as the temperature rises. Results are also given showing the effects of varying duration of heating and of loading. Apart from this, the general relation between load and diam. of impression [see Abstracts Nos. 1868 and 1742 (1908)] holds good with suitable values of the constants. The hardness of carbon steels is a minimum at about 150° to 200° C., and a maximum at about 250°. The temperatures are about 50° lower for iron, and higher for cast iron. There was an almost constant difference between the curves for annealed and cold-worked iron, up to 500°. The hardness-temperature curve for steel resembles the curve relating tensile strength and temperature, but not the yield-point—temperature curve. F. R.

596. *Hardness of Steel at High Temperatures.* **Robin.** (Soc. d'Encouragement, Rev. de Métallurgie, Mém. 5. p. 893, Dec., 1908. Metallurgie, 6. pp. 97–99, Feb., 1909.)—The hardness of various metals was studied by the Brinell method, at temperatures up to 900° C. The hardness of untreated carbon steels is a maximum at about 250°. The curves for steels of different carbon content gradually approach one another at about 850°, and the hardness of high-carbon steels is rather lower at 1,000° than that of low-carbon steels. The hardness of high-speed tool steels is very little affected at 250°, and only falls rapidly above 600°, unless the heating is long continued, in which case the loss of hardness is more considerable, and is important even at 450°. The variation of hardness of chromium steels and of tungsten steels is similar to that of the chrome-tungsten high-speed steels in that they are substantially harder than carbon steels from 250° to 600°. F. R.

597. *Shock Testing, and Definition of Resistance to Shock.* **L. Révillion.** (Soc. d'Encouragement, Rev. de Métallurgie, Mém. 5. p. 887, Dec., 1908. Metallurgie, 6. pp. 99–101, Feb., 1909.)—The author's experiments with a Guillery machine [see Abstract No. 2225B (1904)] lead to the conclusion that using a constant span the energy absorbed is not proportional to the sectional area of specimens of similar shape of cross-section and similarly notched. Although not conclusively proved, however, if the span be increased in the same ratio as the linear dimensions of the section, the energy absorbed appears to be proportional to the sectional area for the same steel. Hence it is essential that in giving results of shock tests, the form, dimensions, and span of the test-piece must be specified. F. R.

598. *Collapse of Columns of Several Bays.* **H. Zimmermann.** (Preuss. Akad. Wiss. Berlin, Sitz. Ber. 6. pp. 180–212, and 12. pp. 348–357, 1909.)—A mathematical solution for a column with several supports at points in its length. There is little novel in the methods of treatment, and the results are of necessity lengthy. It is shown, however, that when the critical load is reached in two parts of a uniform column simultaneously, it is at the same time reached throughout the whole column. When the critical loads for the whole column and one bay are simultaneously reached, the other parts are also at their critical loads. F. R.

599. *Tests of Cast Iron.* **C. Bach.** (Zeitschr. Vereines Deutsch. Ing. 52. pp. 2061–2065, Dec. 26, 1908, and 53. pp. 299–302, Feb. 20, 1909.)—Bending test results are given in complete detail for 5 lots of cast iron (steam pipe,

cylinder, machine castings), in bars of 80 mm. square section, 40, 80, 20 mm. diam., and 100, 80, 60, and 40 cm. span respectively. The average value of the bending strength ($K = 3Pl/2bh^2$) for the square bars is 1/1·2 that for the 80-mm. round bars, and of the deflection 1/1·05. The average values of K for the 80-mm. round bars are from 8,678 to 4,855 kg. per cm.², and deflection at breaking from 9·1 to 12·6 mm. The highest strength in the series was given by 20-mm. bars of a steam-pipe metal, viz., 5,789 kg. per cm.². Tensile, and a number of shock-test results, and chemical compositions are given.

F. R.

600. *Vibration and Whirling of Shafts.* **W. M. Wallace.** (Engineering, 87. p. 817, March 5, 1909.)—The method of equating kinetic and potential energies gives sufficiently approximate solutions when applied to whirling of shafts as well as transverse vibrations of beams or shafts. Morley in "Strength of Materials" overlooks the bending moment due to an overhung load on a shaft, whose whirling is in question, which is equal to $(4\pi^2 I/gT^2)\,dy/dx$, dy/dx being the inclination of the shaft at the point of attachment of the load.

F. R.

601. *Measurement of High Pressure.* **P. W. Bridgman.** (Amer. Acad., Proc. 44. No. 8. pp. 201–217, and No. 9. pp. 221–251, Feb., 1909. Contribution from the Jefferson Physical Lab., Harvard Univ.)—I. *Simple Primary Gauge.*—This consists of a weighted piston $\frac{1}{16}$ in. diam., working in a cylinder containing the working fluid, which also surrounds the exterior of the cylinder for a certain length in order to counteract the tendency to leak, due to the strain of the cylinder. The various sources of error and corrections are discussed in detail. The probable accuracy is 0·1 per cent. and the sensitiveness 2 kg. per cm.² at 7,000 kg. per cm.². Two gauges of this style were compared with one having a $\frac{1}{4}$-in. piston, which was found to respond to about 1/20,000 of the load at 1,000 kg. per cm.², *i.e.*, much more sensitive than a Bourdon gauge of this capacity. The estimate of sensitiveness at the highest pressures is founded upon a comparison with the mercury gauge next described, than which the primary gauge was more sensitive. II. *Mercury Resistance Gauge.*—The mercury resistance gauge is a reliable secondary standard of pressure if proper precautions be used, the principal of which are that the mercury must be pure and carefully freed from air, and that the glass capillary containing the mercury must be seasoned by several applications of pressure over the entire range. The max. error introduced by irregularities in the glass was about 2·5 per cent. The following relation is found between pressure, p, between 500 and 6,800 kg. per cm.², proportional change of resistance, ρ, and temperature t °C. between 0° and 50° C. :—

$$p = \alpha\rho\, 10^{\beta\rho^{1\cdot 08}}\,[1 - a\,(t - 25) - b\,(t - 25)^2],$$

where—

$$\alpha = \log^{-1} 4{\cdot}4871, \qquad \beta = \log^{-1} 9{\cdot}8886 - 10,$$
$$a = \log^{-1} 7{\cdot}1258 - 10, \quad b = \log^{-1} 4{\cdot}4487 - 10.$$

The formula applies to mercury in a capillary of Jena glass 8880*a*, a soft glass which is found to be better than an infusible glass, and gives pressure correctly to 0·1 per cent. Empirical formulæ for specific volume and specific mass resistance of mercury are deduced, the compressibilities being taken from the paper dealt with in the next Abstract. F. R.

602. *Compressibilities of Steel, Glass, and Mercury.* **P. W. Bridgman.** (Amer. Acad., Proc. 44. No. 10. pp. 255–279, Feb., 1909. Contribution from the Jefferson Physical Lab., Harvard Univ.)—The compressibility of a steel rod was found by enclosing it in a steel cylinder, the two being in contact at one end, and measuring the difference between their longitudinal strains. The rod carried a ring, fitting tightly enough not to shake about but loose enough to be moved by the differential strain, and its position was used as the means of measurement of the effect of pressure. Glass tubes were somewhat similarly studied with respect to a steel rod whose compressibility had already been measured. The following results were obtained, with a pressure range of 6,500 kg. per cm.^2: Jena glass No. 3880*a*, $2{\cdot}17 \times 10^{-6}$, No. 3888, $2{\cdot}28 \times 10^{-6}$ per kg. per cm.^2. Bessemer steel boiler-plate, measurements along the direction of rolling, $5{\cdot}298 \times 10^{-7}$; across, $5{\cdot}308 \times 10^{-7}$ per kg. per cm.^2. These agree within the order of experimental errors. Bessemer steel rod, $5{\cdot}16 \times 10^{-7}$. Tool steel, 1·25 per cent. carbon, $5{\cdot}25 \times 10^{-7}$. Bessemer steel rod by an indirect and less accurate method, $4{\cdot}7 \times 10^{-7}$. Commercial Al rod, $11{\cdot}7 \times 10^{-7}$. The compressibility of mercury was studied in a steel piezometer and the following relation obtained: $\Delta V/V_0 = bp + cp^2$, where $b = \log^{-1}(4{\cdot}5681-10)$, $-c \log^{-1}(9{\cdot}2977-20)$; V is volume, p pressure. [See also preceding Abstract.] F. R.

603. *Strength of Pipes and Cylinders.* **C. A. Smith.** (Engineering, 87. pp. 827–828, March 5, 1909.)—As a result of experiments, the author finds that simultaneous torsion and compression lower the yield-point of a metal. The elastic failure of 1-in. diam. steel bars occurs at about the same value of shear stress whether the bar be tested in torsion, tension, or compression, or combined torsion and compression. The fracture of a copper tube, subjected to internal pressure by a closely fitting piston, with wax as fluid, so that the longitudinal stress is moderate, is found to take place at about 45° to the radius. Theoretically the shear stress in a thick cylinder is a maximum on planes inclined at 45° to the radii, so that the tube appears to have failed under maximum shear. F. R.

604. *Production of High Vacua.* **K. Scheel and W. Heuse.** (Zeitschr. Instrumentenk. 29. pp. 38–46, Feb., 1909. Communication from the Physikal.-Techn. Reichsanstalt.)—The pressures obtained in a 6-litre vessel by several methods as follows were measured by means of the McLeod vacuum meter, graduated to 0·00005 mm. The highest vacuum obtained with the Toepler pump was about 0·000025 mm. With Zehnder's mercury pump a limiting pressure of about 0·001 mm. was attained, as also found by Zehnder. A pressure of 0·00006 mm. was attained in 45 min. with a Gaede pump (new model), preceded by water pump, and of 0·00001 mm. in 25 min. when preceded by an oil pump. v. Reden's pump and Rosenthal's modification are practically double-acting Toepler pumps, and gave practically the same final pressure as Toepler's, but in a shorter time. By use of charcoal cooled in liquid air a fall of pressure from 12 to 0·0012 mm. was obtained in 48 min. With uncooled charcoal a fall from over 0·1 to 0·0018 mm. in 32 min., and with the same charcoal in liquid air to 0·00026 mm. in a further 2 hours was obtained. Proceeding in stages—water pump, Gaede pump, carbon and liquid air—which are planned according to the size of apparatus to be evacuated, a vacuum of 0·00001 mm. and even less can be attained with fair rapidity (40 min.). F. R.

605. *Flow of Air through Pipes.* **A. H. Gibson.** (Phil. Mag. 17. pp. 389–402, March, 1909.)—The coefficient f in the formula $\delta p = flv_m^2/2gm$ depends on the condition of the internal surface of the pipe, the diam. (d), mean velocity of the air in it (v_m), mean pressure p_m, and temperature (T° abs.). δp is the drop of pressure in length l, m the hydraulic mean depth = diam./4. On certain assumptions a formula is obtained: $\delta p = k\,d^{n-3}\mu^{2-n}(pm/RT)^{n-1}v_m^n l$. With stream-line motion, *i.e.*, below the critical velocity, $n = 1$, and the formula becomes $\delta p = k\mu v_m l/d^2$, which is verified by the experiments of the author and Grindley [see Abstract No. 554 (1908)]; k is a coefficient, μ is the viscosity coefficient. As the variation in resistance with temperature is small, the factors involving temperature may be regarded as sensibly constant in the first place, and the logarithmic form may be deduced—

$$\log(\delta p p_m d^3/l) = n(\log p_m v_m d - \log B) + \log A.$$

From the published data of Riedler, Gutermuth, Stockalper, Brix, Grindley, and the author it is found that in tests of atmospheric temperature, say 66° F., $A = 125 \times 10^{-8}$, $B = 6{\cdot}60$, and n for ordinary cast- or wrought-iron pipes has the values shown in the following table:—

Diam. (inches)	3	5	7	9	12
n..................	1·88	1·81	1·79	1·775	1·77

The formula with d and l in feet is then $\delta p = 0{\cdot}00000125\,p_m^{n-1}v_m^n l/6{\cdot}6^n d^{3-n}$ lbs. per sq. in. Considering the effect of temperature variation we have for a constant mean velocity and pressure $\delta p/\delta p_1 = (\mu/\mu_1)^{2-n}(T_1/T)^{n-1}$, and for constant mean pressure and $\delta p = \delta p_1$, $(v_{m1}/v_m)^n = (\mu/\mu_1)^{2-n}(T_1/T)^{n-1}$. With $n = 1{\cdot}26$, experimental results on a lead pipe of ⅜ inch bore are in almost exact agreement with calculated values. The complete formula for δp given above is somewhat cumbrous, and the use of an additional coefficient K in the last form given above is instead proposed. K is plotted with respect to temperature and values of n. When n is less than 1·88, K increases with temperature; for greater values of n, K decreases as temperature increases. When $n = 1{\cdot}80$ (the mean value for a wrought-iron pipe) K varies approximately 1 per cent. per 10° F. F. R.

606. *Flight of Birds.* **L. Thouveny.** (Comptes Rendus, 147. pp. 1466–1468, Dec. 28, 1908.)—Discusses the flight of the hawk, falcon, and seagull from the point of view of economy. In a uniform horizontal breeze no indefinite soaring is possible. It becomes possible when the wind is an ascending one. Birds utilise variations in the strength of the wind for soaring, and describe curvilinear paths, ascending during the stronger gusts.

E. E. F.

607. *Flight of Birds.* **F. W. Lanchester.** (Engineer, 107. pp. 198–199, Feb. 19, and pp. 225–226, Feb. 26, 1909. Paper read before the Birmingham Natural History and Philosoph. Soc., Jan. 19, 1909.)—The gliding angle of birds varies from 1 in 14 to 1 in 10. The gliding angle cannot, on account of skin friction, be diminished indefinitely without increasing the velocity. It is, in fact, independent of the velocity. In insects the diminution of weight makes a diminution of skin friction imperative, and plane wings take the place of the pterygoid forms. In plane wings the skin resistance along the upper surface is neutralised or even rendered negative by eddies. Some small birds minimise skin friction by closing their wings entirely for portions of their flight. This "leaping" flight consists of a series of parabolic curves. The enormous speeds sometimes attained in migratory flights may be partly accounted for by air currents of favourable directions. Perhaps, also, the tenuity of the upper air renders rapid flight easier. E. E. F.

608. *Use of the Torsion Pendulum for Determination of Gravity.* **P. Pagnini.** (N. Cimento, 16. pp. 436–445, Nov.–Dec., 1908.)—A series of experiments with torsion pendulums consisting of leaden weights suspended from wires of invar or Pt-Ag alloy, about 1 m. long, and of diam. 0·477 and 0·5 mm. respectively, has shown that neither metal gives reliable readings, the former being too susceptible to variation of temperature and pressure, whilst the latter undergoes a species of *fatigue*. Better results have been obtained with quartz threads as the suspending material, since although the modulus of elasticity of quartz varies with change of temperature, the ratio of change in period of oscillation to change of temperature is almost constant, and a correction for temperature can therefore be applied. W. H. St.

609. *The Spectrum of Light from Overcast Skies.* **E. L. Nichols.** (Phys. Rev. 28. pp. 122–131, Feb., 1909.)—The author has examined the intensity in different parts of the spectrum of the light received from the sky on overcast or partially overcast days. The experiments were made, mostly in the Alps, with a spectrophotometer of the Lummer-Brodhun type, so arranged that one collimator pointed to the zenith while the other received the light from a comparison source of nearly constant intensity and composition. An acetylene flame was used for the purpose. Measurements were made throughout the visible spectrum from the extreme red at 0·74 μ to the extreme violet at 0·38 μ. The results are shown by curves in which the scale is entirely arbitrary, and thus they have only comparative value. On completely overcast days the curves were very simple, and similar to those obtained on some days of cloudless sky. They show a steady falling off from violet to red, with a slight droop in the extreme violet. On days of intense blue sky this droop in the violet is entirely absent, and there is also a relative increase in the brilliancy of the red end of the spectrum. The curves for misty days show a very characteristic maximum in the blue at 0·42 μ. This maximum in the blue appears regularly as the day advances in the mountainous regions of Switzerland during fine summer weather, when there is a gradual formation of mist in the upper atmosphere, gathering into cloud masses with a tendency to thunder showers in the afternoon. The author gives some interesting diagrams showing the diurnal variation from the simple curve for a cloudless sky in the early morning to the typical midday curve with the maximum at 0·42 μ and back to the simple curve in the evening. R. G. K. L.

610. *The Duration of Showers at Batavia.* **J. P. van der Stok.** (Konink. Akad. Wetensch. Amsterdam, Proc. 11. pp. 555–568, Feb. 25, 1909.)—Hourly observations of rainfall have been conducted at Batavia since 1866. The author discusses this material from the point of view of duration of rainfall. The percentage number of hours during which rain fell exhibits a well-marked annual period, the figures varying from 17·5 per cent. in Feb. to 1·8 per cent. in Aug. The second table exhibits the frequency of showers of different durations. By duration of a shower the author wishes us to understand, not the duration of continuous rainfall, but the number of consecutive hours in which rain was recorded. There are only 11 instances out of a total of 8,190 of "showers" exceeding 24 hours in length, but in Feb. and March there are three instances of 100, 109, and 147 hours. The annual variation of the frequency of duration of showers shows minima in April and Aug. The author proceeds to apply Pearson's frequency formulæ, type III., to the data.

R. G. K. L.

611. *Variation in the Distribution o Pressure over the Globe.* **H. Arctowski.** (Comptes Rendus, 148. pp. 589–591, March 1, 1909.)—The paper carries a step further the well-known work of Hildebrandsson on the centres of action of atmospheric disturbance [K. Svensk. Vetensk. Akad. Handl., 29. No. 8], in which it was shown that, for individual months, the sign of the difference of pressure from the long-period average is the same over vast regions on the earth's surface. The author has applied the same principle to longer periods, viz., years and lustra. He finds that even when periods of five years are considered there is the same well-marked similarity in the character of the divergence from the (25-year) average over vast areas of the earth's surface. There is thus a stability in the main features of atmospheric circulation which Hildebrandsson's method of working with individual months failed to reveal. From the charts which accompany the paper it appears that the variations of pressure occurring in Arctic regions are much greater than those in other latitudes—a fact which confirms the view put forward by Petterson that the poles are the chief "centres of atmospheric action." R. G. K. L.

612. *Variation in Height of the Stratosphere (Isothermal Layer).* **L. Teisserenc de Bort.** (Comptes Rendus, 148. pp. 591–594, March 1, 1909.)—The author forms the following generalisations regarding the isothermal layer, from the available data obtained with registering balloons. The arrest of the fall of temperature with increase of height at a certain altitude and its replacement by a state in which the temperature as we rise further shows small oscillations about an isothermal state, is a phenomenon which is common to all parts of the globe. The level at which the layer in which temperature decreases with altitude ceases and gives place to an isothermal layer, is greater as we approach the equator. The surface of separation is, in general, at a greater altitude above regions of high (surface) pressure than above regions of low pressure. It attains its greatest height in front of large depressions, in the region bordering on regions of high pressure. On the other hand, it is from 3 to 4 km. lower in the rear of a depression, and attains its minimum height over what is known as a trough of low pressure.

R. G. K. L.

613. *Theory of Geological Climates.* **H. F. Reid.** (Science, 29. pp. 27–29, Jan. 1, 1909.)—Several points of adverse criticism on Manson's theory of geological climates are discussed in detail. Manson supposes that during Palæozoic times the earth's climate was practically uniform from equator to poles, and torrid temperatures were everywhere maintained by heat derived from the earth and warm oceans, this heat being prevented from radiating into space by a blanket of clouds surrounding the whole earth. Recognising that the heat brought to the earth's surface by conduction is not enough to keep up a high atmospheric temperature, Manson also suggested that heat might be evolved by erosion, hot springs, volcanic eruptions, &c. Reid calculates the amount of this heat, assuming Becker's value of the consolidation temperature as 1,800° C., and finds that the period elapsing since such time to be of the order 4×10^6 years, which is only pre-Mesozoic. Further, it is difficult to realise conditions of *uniform* cloud covering, as an atmosphere heated at its base is in unstable equilibrium, and convection currents would immediately be set up, carrying the moist air to high altitudes, and resulting in heavy rains and partial clearing of the atmosphere. Reference is also made to Gregory's view that throughout geological times there has been a zonal distribution of temperature very similar to that of the present day. It can readily be shown that the heat received by conduction from the earth is insignificant in comparison with that received from the sun, the latter being about 2,000 times greater. From these facts the author concludes that the heat conducted from the earth's interior could not have a material effect in modifying the surface temperature or atmospheric phenomena. C. P. B.

614. *Experiments concerning the Submarine Elevation of Mountains.* **A. Tornquist.** (Preuss. Akad. Wiss. Berlin, Sitz. Ber. 4. pp. 87–104, 1909.)—Peculiarities in the stratification of sedimentary rocks are now ascribed to subaqueous processes which took place at the bottom of the sea and not, as was formerly assumed, after the elevation of the strata above sea-level. The author studies certain geological features of the Alps from this point of view, and describes some experiments which he has conducted together with W. Klien and R. Jonas, on the depth to which various objects will penetrate into loose and firm sand lying under water, and on the rates of their movements. A cylinder, 18 cm. in diam., was charged with fine sand ($\frac{1}{4}$ mm. grain) and water, keeping the air out. When the cylinder was tapped with a piece of rubber hose 250 times, the sand settled quite firmly, and contained only 12 per cent. of water a few cm. below the surface. Cones, hemispheres, discs, and rods of brass up to 60 kg. (together with the tackle) in weight, and even bodies of density 2, settled in the loose sand, first with a kind of acceleration, then at a slower rate; when the object was small, concussions increased this rate very much, less so with larger objects. In firm sand the objects must be denser than the sand to sink. Larger blocks are stopped at comparatively smaller depths. But they also sink, and the author considers that large blocks penetrate into soft sediments and decay there, forming conglomerates. Experiments with clay and other sediments are to follow, and R. Jonas is studying the loose sand of the Kurische Nehrung (Eastern Baltic). The paper is chiefly geological. H. B.

615. *Principal Seismic Waves.* **de Montessus de Ballore.** (Comptes Rendus, 148. pp. 200–201, Jan. 18, 1909.)—In attempting to trace the oscillations recorded during the principal phase of an earthquake the regions of occurrence of notable movements are described in detail. Where a long fault occurs there is seen to be evidence of much more complicated movement than a simple slide, often shown as apparent oscillations before the final position was assumed. It is possible that these movements correspond to the oscillations shown on the principal seismographic phases. C. P. B.

616. *Distribution of Fraunhofer Lines in the Spectrum of the Solar Corona.* **A. Amerio.** (N. Cimento, 16. pp. 430–435, Nov.–Dec., 1908.)—The frequent absence of Fraunhofer's lines from the spectrum of the inner solar corona is attributed to (1) the great difference between the angles of incidence and

reflection for each point, (2) the large number of reflecting particles, (3) their diverse direction with respect to the earth, and (4) the Doppler-effect produced by some falling back on the sun whilst others become detached from it. In the external corona the conditions are more favourable for the formation of Fraunhofer's lines, the angles of incidence and reflection being more uniform, and the Doppler-effects less pronounced and all in the same sense. W. H. St.

617. *Depth of the Hypocentre of the Calabrian-Sicilian Earthquake of December* 28, 1908. **E. Oddone.** (Accad. Lincei, Atti, 17. pp. 186–192, Feb. 21, 1909.)—Employing the variant of Kövesligethy's formula $\Gamma/\Gamma_0 = (h/r)e^{-\frac{a}{R}(r-h)}$ where Γ is the max. acceleration of the earthquake at a given station, Γ_0 that at the epicentre, h the unknown depth of the hypocentre, r the minimum distance between the hypocentre and a point on the earth's surface, R the radius of the earth in km., and a a second unknown representing the radial coefficient of absorption of the earth, and combining it with Cancani's formula $G - G_0 = 8 \log \Gamma/\Gamma_0$, G_0 and G being the degrees of the seismic scale at the epicentre and at the given station, the author deduces the relation—

$$[(8a/R)h \log e + 8 \log h] - [(8r/R) \log e]a = G - G_0 + 8 \log r,$$

and hence calculates the depth of the hypocentre of the earthquake of Dec. 28, 1908, as 9 km. [See Abstracts Nos. 1826 (1906) and 1805 (1907).] W. H. St.

618. *Interaction of Sun-spots.* **P. Fox** and **G. Abetti.** (Astrophys. Journ. 29. pp. 40–45, Jan., 1909.)—A general inquiry into spot phenomena reveals an apparent correlation of the spots of the two hemispheres. From the records of Carrington and Spoerer the number of coincidences of spots in both hemispheres is about equal to the probability of coincidence from chance arrangement. However the general case may stand, in individual cases there appears to be evidence of a physical connection. Photographs taken with the Rumford spectroheliograph are reproduced to show the sympathetic growth of a spot area, the usual precedent of a flocculus antedating the spot being very clearly shown. As the spots approach the equator towards the end of the sun-spot maximum, and the distance between north and south neighbours lessens, an attempt was made in Sept., 1908, to ascertain if there was any normal connection, at any level, between the members of such a spot-pair. Other photographs taken in hydrogen (Hα) light show the complete life-history of an intense eruption following a southern spot, which extended actually as far as the borders of the northern companion, the whole phenomena of eruption and decline occupying less than 4 hours. The corresponding photographs in calcium light show much less disturbance. Measurements of the line displacements during the violent periods indicated an initial descent velocity of about 100 km. per sec. From special measurements it was determined that from Sept. 8–12 the southern spot remained unmoved in its position, while the northern spot had approached the other 8°·8 in longitude and 1°·7 in latitude. C. P. B.

619. *Variations of the Sun's Figure.* **F. R. Moulton.** (Science, 29. p. 155, Jan. 22, 1909.)—From an investigation into the possibility of changes in the form and dimensions of the sun, the author gives the following conclusions: The sun is oblate and the theoretical difference in its polar and equatorial diams. is less than 0″·01. Its gravitational oscillations are expressible in spherical harmonics whose periods depend on their order. The change of the sun's diam. by 0″·1 would change its rotation period by 7·8 minutes. The expansion of the sun by 0″·1 would decrease its temperature (assuming its specific heat as unity) by more than 1,400° C.

C. P. B.

620. *Fluctuations in the Moon's Mean Motion.* **S. Newcomb.** (Roy. Astronom. Soc., Monthly Notices, 69. pp. 164–169, Jan., 1909.)—The author has brought to completion his study of the moon's mean motion based on observations having an extreme range in time of about 2,600 years, and considers that the results seem to prove the actuality of the large unexplained fluctuations in the motion. The feature of most interest is the great fluctuation with a period of between 250 and 300 years. No idea can be formulated as to the cause of this variation, and the most that can be said is that the varying forces are sufficient to bring about a change of annual motion amounting to between 0″·5 and 1″·0 by acting during a period of perhaps 4 to 6 years. It is thus not possible to predict the future motion of the moon with precision. If we require the ephemerides of the moon's longitude to be as exact as possible, we must correct the tabular mean longitude from time to time by observations.

C. P. B.

621. *Apparent Diameter of a Fixed Star.* **A. S. Eddington.** (Roy. Astronom. Soc., Monthly Notices, 69. pp. 178–180, Jan., 1909.)—Induced by the paper of MacMahon [see Abstract No. 404 (1909)], the present author shows that the diffraction of the star's light by the moon's limb must have a very considerable effect on the possibility of getting a reliable measure of the star's diam. It is shown that the distance of the first minimum from the geometrical shadow is about 36 ft., and the spurious occultation diam. due to this diffraction of light at the moon's limb is about 0″·008, which would be great enough to mask the true diam. in most cases.

C. P. B.

622. *Photographic Observations of Comet Morehouse,* 1908c. **E. E. Barnard.** (Astrophys. Journ. 29. pp. 65–71, Jan., 1909.)—Since the last notes [Abstract No. 33 (1909)] the comet presented a different series of phenomena, marked chiefly by long slender streamers at small angles to the main tail, and also by convoluted forms in the tail itself, these new features being especially prominent on the photographs taken on Nov. 14, 15, 16, 17, 18, and 19, several of which are reproduced. The various deflections shown at times by the tail streamers are considered to indicate the presence of some retarding medium in interplanetary space.

C. P. B.

623. *Spectrum of Comet Morehouse,* 1908c. **E. B. Frost** and **J. A. Parkhurst.** (Astrophys. Journ. 29. pp. 55–64, Jan., 1909.)—Photographic exposures on the spectrum of the comet were commenced with the Zeiss doublet and objective prism at the Yerkes Observatory on Oct. 28, 1908. The scale is but small, so that very intense images were obtained, giving a spectrum 8·0 mm. long between H_β (4861) and H_θ (3798). Twenty-one satisfactory plates were obtained on eleven dates, ending with Dec. 2, after which the comet was beyond reach. Wave-length determinations were made by means of a series of slit-spectrograph comparisons, combined with the trails of star

spectra near by. In the discussion of the spectra one important conclusion is that no continuous spectrum was shown on any of the plates, indicating the relative feebleness of the reflected light. Regarding the carbon bands, the third and fourth appear to be certainly present, while the fifth is absent. The third cyanogen band is certain, the first and fourth very probable, while the second appears to be absent. Certain differences were found compared with the determinations of other observers, notably in the reported duplication of several of the bands, which the present authors do not find on their plates. The relation between the various parts of the comet structure is well shown on reproduction of the spectra, side by side with direct photographs taken with the Bruce camera; many of the spectral images extend far into tail streamers. On tracing the relation of these tail-streamer spectra in comparison with the "head" bands, conspicuous differences in behaviour are noticed. Thus the streamer proceeding from the knot at 4711, though undoubtedly present, is very weak compared to the streamers from the fainter knots at λ4017 and λ4561. It is also seen that the knots deficient in tail material extend perceptibly farther on the side opposite the tail (*i.e.*, towards the sun) than the other knots. So far as can be seen, the spectrum of the comet as a whole did not appreciably alter during the time these spectra were obtained. Incidentally it is noted that the straight tails of the comet should, according to Brédikhine's theory, have shown the spectrum of hydrogen, instead of that of carbon and cyanogen. **W. W. Campbell** and **S. Albrecht.** (Astrophys. Journ. 29. pp. 84–87, Jan., 1909.)—Photographic and visual observations of the spectrum of the comet were made with a single-prism spectrograph attached to the 36-in. Lick refractor, the lines photographed being tabulated. The second cyanogen band was absent. The increased photographic magnitude over visual brightness is now accounted for by the relatively great intensity of the blue and violet bands, the continuous spectrum being at the same time extremely weak. [See also Abstract No. 1914 (1908).] C. P. B.

624. *Selective Absorption and Diffusion of Light in Interstellar Space.* **G. A. Tikhoff.** (Comptes Rendus, 148, pp. 266–269, Feb. 1, 1909.)—[See Abstracts Nos. 1242, 1398 (1908).] The Pleiades were photographed through four different light-filters, letting pass, respectively, the ultra-violet (360–405 μμ), indigo-violet (400–470 μμ), yellow-green (495–610 μμ), and orange rays (575–670 μμ). If the nebulous matter in the Pleiades, or the space separating the group from the earth, absorbs selectively, and if the faint stars of the group are on the average more distant from the earth than the bright stars, then the relative brightness of the faint and bright stars should vary from one end of the spectrum to the other. This agrees with what was found. A cursory inspection of the plates, without measurement or calculation, suffices to show that (apart from a few isolated exceptions) the difference in brightness between the bright and faint stars of the Pleiades increases to a surprising extent, in passing from the orange to the ultra-violet. The photographs were taken at Simeïse Observatory, Crimea, in Nov. and Dec., 1908, with an astrograph having two identical cameras with Zeiss "Unar" objectives, of 120 mm. diam., and 600 mm. focus. Prints from four of them, enlarged fourfold, were laid before the Academy. The chief stars on the photographs decrease in brightness from the ultra-violet to the orange, while the faint stars increase sensibly in number and brightness in the same direction. The difference is especially remarkable in passing from the ultra-violet to the indigo-violet. The variation in the general aspect of the group is such that the Pleiades are hardly to be recognised on the orange plate

The same phenomenon was found in making measures and calculations from photographs of the Pleiades and of Coma Berenices taken at Pulkowa in spring, 1908, with the Brédikhine astrograph, some on ordinary plates without filter, some in the yellow-green rays through a filter. Several exposures were made on one plate, with durations in geometric progression. On each plate pairs of images of different stars were sought for, equal in intensity but corresponding to exposures as different as possible. Denoting the brightness of the two stars by I and *i*, and the corresponding durations of exposure by *t* and T, the usual equation connecting these quantities is $It^p = iT^p$. Supposing the difference in brightness of the two stars to be greater in the photographic rays than in the yellow-green rays, then *p* should be smaller for the plates taken in the photographic rays than in the optical rays. This is what was actually obtained; for the photographic rays, the values of *p* ranged from 0·67 to 0·79, and for the yellow-green rays, from 0·91 to 0·96. The increase of *p* for photographs taken in the optical rays is also in accordance with the hypothesis of a scattering of light by particles in space. This phenomenon of increasing difference of stellar brightnesses with diminishing wave-length is displayed on all the author's photographs taken during the last three years in different parts of the sky. It would thus appear that selective absorption or diffusion of light, or both together, take place throughout the extent of celestial space, though very probably the phenomenon varies in intensity in the different regions of space. The discovery may, among other consequences, facilitate the determination of stellar distances. Photographs in the extreme red rays, which are nearly exempt from the influence of cosmic enfeebling, would serve as a basis for such a scheme. It follows from the above researches that stellar magnitudes determined visually cannot safely be made use of in photographic work unless the photographs are taken with a visual objective. A more detailed account of the author's researches will appear shortly in the "Mitteilungen" of the Pulkowa Observatory. A. E.

625. *The Absorption of Light in Space.* **J. C. Kapteyn.** (Astrophys. Journ. 29. pp. 46–54, Jan., 1909. Contribution from the Mount Wilson Solar Observatory, No. 31.)—The great obstacle in the way of knowledge of the real distribution of the stars is the uncertainty as to the amount of loss their light suffers on its way to the observer. This loss is here, for brevity, designated as absorption, though scattering of light is included. It is the author's opinion that there can be little doubt about the existence of absorption in space, and even that a good guess as to the order of its amount can be made. It is known that space contains an enormous mass of meteoric matter, which must necessarily intercept some part of the star-light. Space must also contain a considerable amount of gas, owing to loss of coronal gas by the sun and, presumably, by other stars, that lost by comets, &c.; might not this gas, in a thickness of hundreds of light-years, cause an appreciable absorption of light? Further, the author has shown, in former papers [see Astronom. Journ. No. 566, and Publications of the Groningen Laboratory, Nos. 11 and 18], that the collected data fit either of the two following assumptions: First, that the universe is completely transparent, and the stars gradually thin out as we recede from the sun. Second, that absorption of light of a determined small amount occurs, and the star density is the same at different distances from the sun. The second assumption seems the more probable, since the first would assign to our sun a very exceptional place in the stellar system, viz., the place of maximum density. In the former papers methods were suggested by which the average value of the absorption might be obtained, and the value of 0·016 magnitude for a distance of 88 light-years (corresponding to a parallax of 0″·1) was found, merely, however, as an indication of the probable *order* of magnitude of the absorption, not for acceptance. The present paper deals with a different method depending on whether the interstellar absorption turns out to be more or less selective. If the absorption and scattering of light by meteoric matter is really sensible, then the violet end of the spectrum must be more strongly affected than the less refrangible rays. This inference is justified by Tikhoff's observations [see preceding Abstract]. If there is absorption by gas in space, it would produce space-lines or space-bands, of which indications might be obtained by comparing stars having spectra of the same class, but widely different proper motion. A criterion of the reality of the results would be afforded by the fact that such space-lines must not share in that part of the radial motion which is due to the star's own motion. But so far there is no evidence as to the real occurrence of such gas-lines or bands. Recently, however, the author has found some results in the Harvard Annals, 28, Part I., which can be explained most readily by a scattering of light by meteoric matter causing a general absorption particularly strong in the violet. In observations of spectra of bright stars, Miss Maury remarks that the stars of Class XV.*a* appear to fall into two divisions, exhibiting a slight difference in the degree of general absorption in the violet. The stars *a Bootis* and *a Cassiopeiæ* are typical of the two divisions, the absorption beyond λ4807 being more conspicuous in the second. The distinction is a very difficult one in practice, as the absorption indicated also varies with the photographic density, but Miss Maury states that "there seems to be sufficient ground for believing that the distinction is a real one." The author has also been led to think that the distinction is real, and that the most natural way to account for it is by space-absorption. If this explanation be well founded, then the stars of the *a Cassiopeiæ* group must be further removed from the solar system than the stars of the *a Bootis* group. A careful examination of the proper motions tends to show that this is the case, the proper motions in the *a Bootis* division exceeding, as a rule, those in the other group considerably. Granting the reality of the difference in the distance of the two sets of stars, it does not necessarily follow that the difference in their spectra is due to space-absorption. For as the average magnitude of the stars in the two sets is about the same, the total luminosity of the more remote *a Cassiopeiæ* stars must be greater than that of the *a Bootis* stars. The result may therefore also mean that for stars of the same spectrum, the light of the brighter is relatively weaker in the violet rays. Whichever view be more probable, the phenomenon seems worthy of closer investigation. The determination of the space absorption, apart from its important bearing upon the questions of the distribution and distance of the stars, would help to give an insight into their true spectra. Possibly the curious fact, pointed out by Huggins, that stars of Secchi's second type often show spectra which, in the more refrangible part, are more intense and extensive than in the spectra of the first type, is simply due to space-absorption. For it is well known that the average distance of stars of the second type is considerably smaller than that of first-type stars of equal magnitude. In the programme of the stellar work for the 5-ft. reflector of the Mount Wilson Solar Observatory some stars chosen with special reference to the subject of the present paper will be included. A. E.

626. *Colours of Stars in Globular Cluster M* 13 (*Herculis*). **E. E. Barnard.** (Astrophys. Journ. 29. pp. 72–75, Jan., 1909.)—In 1900 the author called atten-

tion to certain abnormal stars in the globular cluster M 13, their photographic magnitude being relatively greater than that measured visually, and suggesting that their light was stronger in blue or actinic rays. Recently photographs of the cluster taken with the Potsdam photographic refractor and with the Yerkes 40-in. refractor and colour screen have been compared with a Zeiss stereo-comparator, and it was then found that in addition to the stars with preponderance of blue rays there were others with preponderance of yellow. The two variables in this cluster are both blue stars, with periods of 5·1 and 6·0 days. C. P. B.

627. *Orbit of a Coronæ.* **F. C. Jordan.** (Science, 29. pp. 155–156, Jan. 22, 1909.)—The binary character of this star was discovered by Hartmann from 6 plates obtained at Potsdam during 1902 and 1903; its spectrum is of the type 1 or 2 in Vogel's classification. From 137 plates obtained at Allegheny between April 2, 1907, and Sept. 11, 1908, the velocity was found to have a total range of 69·86 km. As the periastron point is in the fourth quadrant, the ascending branch of the velocity curve is steeper than the descending. The centre of gravity of the system has practically no velocity in the line of sight. No trace of a secondary spectrum could be seen. C. P. B.

REFERENCES.

628. *Dividing Engine.* **G. T. McCaw.** (Roy. Astronom. Soc., Monthly Notices, 69. pp. 226–228, Jan., 1909.)—Details of testing of a 55-cm. circle ruled on a new dividing engine made by E. R. Watts and Son, South London. The range of errors is from + 1″·8 to − 1″·7. C. P. B.

629. *Elementary Solutions in Strength of Materials.* **L. E. Picolet.** (Frank. Inst., Journ. 167. pp. 131–149, Feb., 1909.)—By a combination of algebraical and graphical methods, solutions of problems are obtained without the calculus, and the examples given go as far as combined direct and shear stress, and the theorem of three moments. F. R.

630. *Statistical Theory of Capillarity.* **L. S. Ornstein.** (Konink. Akad. Wetensch. Amsterdam, Proc. 11. pp. 526–542, Feb. 25, 1909.)—In 1893 van der Waals gave a theory of capillarity leading to results which have been shown by E. O. de Vries to agree sufficiently with observation. This theory involved the hypothesis that the entropy of an element of volume is a function only of the number of molecules it contains and of that of their collisions. By the use of the statistical method of Gibbs the present author deduces the condition for the equilibrium of the capillary layer without using the above hypothesis and yet obtains the results previously found by van der Waals. E. H. B.

631. *Messina Earthquake of December* 28, 1908. **J. C. Solà.** (Comptes Rendus, 148. pp. 202–203, Jan. 18, 1909.)—Observations of the Messina earthquake tremors were recorded at the Fabra Observatory, Barcelona. Calculations of the position of the epicentre by the usually accepted formulæ appeared to give very discordant results, the only one coming near being Jordan's equation, giving 1,094 km. instead of the correct distance, 1,200 km. C. P. B.

632. *Seismograms of Earthquake, January* 23, 1909. **R. T. Glazebrook.** (Nature, 79. p. 428, Feb. 11, 1909.)—Reproductions from the original seismographic traces with the Milne twin-boom instrument at the new magnetic observatory at Eskdalemuir, Dumfries-shire. C. P. B.

LIGHT.

633. *Photographic Zenith Telescope.* **A. de la Baume Pluvinel.** (Comptes Rendus, 148. pp. 147–150, Jan. 18, 1909.)—An objective (0·10 m. aperture, 1·17 m. focus) is fixed at the upper end of a vertical tube, with its lower surface rendered exactly horizontal. Below the objective, at a distance equal to half its focal length, is a mercury trough. The image of a star will then be formed on the posterior surface of the objective. Close to the objective there is then placed a photographic plate with its sensitive surface against the lens; the plate is only a narrow strip about 2 cm. wide, and a little longer than the diam. of the objective. The length of the plate is oriented so as to be parallel to the plane of the meridian, so that the star-trails will be parallel to the short side of the plate. For measuring the distance of each trail from the zenith point the part of the objective behind the sensitive plate is silvered, and a rectangular *réseau* traced on it. By means of a light placed outside the objective, at its focal distance, an image of this *réseau* is projected on each photographic plate, and this is developed with the star-trails. It is expected that the astronomical latitude can be determined to within 0″·8. By arranging an occulting shutter to cover the objective at definite known instants the star-trails are interrupted, and the time of meridian passage can be determined to 0′·1. C. P. B.

634. *Dispersion of Light in Acetylene and Methane.* **S. Loria.** (Acad. Sci. Cracovie, Bull. 10. pp. 1059–1067, Dec., 1908. Physikal. Inst. d. kgl. Univ., Breslau, Nov. 30, 1908.)—The light from a Nernst filament is passed through a constant-deviation spectrometer into a Michelson interferometer, in the two arms of which are tubes for containing the gas under examination. By passing light into the interferometer from different parts of the spectrum the change in the number of bands with wave-length is observed, and the corresponding change of refractive index with wave-length calculated [see also Abstract No. 1082 (1908)]. Values are given for the refractive index of the gases for different wave-lengths, *e.g.*, for methane, 1·0004404 at 0° and 760 mm. for $\lambda 6{\cdot}585 \times 10^{-5}$ cm., and for acetylene, 1·0005604 for $\lambda 6{\cdot}708 \times 10^{-5}$ cm. The constants of Cauchy's dispersion formula are also calculated for the two gases. G. E. A.

635. *Deviation of Oblique Rays by Prisms.* **H. S. Uhler.** (Amer. Journ. Sci. 27. pp. 223–228, March, 1909.)—An examination of the case in which the rays traverse the prism by paths which do not lie in principal sections of the prism. If D and D′ denote respectively the deviations of a ray not in a principal section, and of the projection of the same ray on a principal section, and i_1 the angle which the incident ray makes with such a section, it is proved that $\sin \frac{1}{2}D = \sin \frac{1}{2}D' \cos i_1$. From this it follows that, contrary to the usual statement, when $\cos i_1$ is less than 1, D is less than D′. The bearing of the formula on the question of minimum deviation is also treated, and the conclusion is drawn that the text-book formula, $\cos \frac{1}{2}D = \cos \frac{1}{2}D' \cos i_1$, must be replaced by the above relation unless it is explicitly stated that D and D′ of the cosine relation are the supplements of the corresponding deviations as involved in the other equations of the subject. G. E. A.

636. *Electric Double Refraction in CS_2.* **W. König.** (Ann. d. Physik, 28. 2. pp. 418–420, Feb. 4, 1909.)—A criticism of Elmen's paper [see Abstract No. 529 (1906)] which describes experiments on the electric double refraction of carbon disulphide with low potential-gradients, according to which the factor in Kerr's law is not constant, but increases with low p.d. This result appears improbable, and the author attributes the apparent rise in the value of the factor to a small constant error in the measurement of the angle of rotation of the compensator. The remarks are then extended to the general case $y = af(x)$, where a is a constant and $f(x)$ disappears with x, to point out the danger of assuming that inconstancy of the ratio $y/f(x)$ is a decisive criterion of the invalidity of the law involved. G. E. A.

637. *Ultramicroscopic Vision.* **J. E. Barnard.** (Nature, 79. pp. 489–490, Feb. 25, 1909.)—The limits of ultramicroscopic vision are difficult to define, and it is more than probable that many of the particles observed when a powerful beam of light is passed through a darkened room are ultramicroscopic. Methods of extending the limits of visibility of the microscope are described. The simplest, and one of the earliest, methods of illuminating the object by means of light projected at various angles to the optical axis is the "spot lens." Mention is also made of Siedentopf's ultramicroscope. In recent developments of dark-ground illumination the parabolic illuminator of Zeiss is capable of use in observing minute living bacteria; and Messrs. Leitz have also designed a reflecting condenser for a similar purpose. Two necessary conditions for the observation of ultramicroscopic particles are: A sufficiently strong source of light, and the arrangement of the incidence of this light on the object so that only those particles are illuminated which are in the field of view. G. E. A.

638. *Influence of Extreme Regions of the Spectrum on the Phenomena of Solarisation.* **A. G. de Moncetz.** (Comptes Rendus, 148. pp. 406–407, Feb. 15, 1909.)—The author has investigated the influence of the extreme rays of the spectrum in restoring the intensity curve of solarised photographic plates, and finds that the infra-red and ultra-violet regions possess the power of restoration, while the blue rays have the contrary effect. E. C. C. B.

639. *Luminous Efficiency and the Mechanical Equivalent of Light.* **C. V. Drysdale.** (Roy. Soc., Proc. Ser. A. 80. pp. 19–25, Dec. 9, 1907. Abstract.)—The luminous efficiency is ordinarily taken to mean the ratio of the luminous radiation to the total radiation from a source. In symbols, the luminous radiation may be denoted by $\int_{\lambda_1}^{\lambda_2} I d\lambda$, where $\lambda_1 = 0{\cdot}39\,\mu$ and $\lambda_2 = 0{\cdot}76\,\mu$, the limits of the corresponding integral for the total radiation being 0 and infinity. Guilleaume, however, defines the luminous efficiency as the ratio of the "equivalent luminous radiation" to the total radiation. The equivalent luminous radiation is expressed by $\int_0^\infty \kappa I d\lambda$, where κ is a function of λ that is proportional to the luminosity, and is taken equal to unity for $\lambda = 0{\cdot}54\,\mu$, which is the wave-length corresponding to that of max. luminous utilisation of energy. The mechanical equivalent of light was determined by measuring the intensity in watts per cm.² of the radiation at a given distance

from the source by a bolometer, and also the intensity of the illumination at the same distance from the source. A small source of light of great intensity was employed, and by means of a lens and a carbon bisulphide prism an approximately pure spectrum was obtained at the photometer and bolometer box. From his experimental results the author concludes that an ideal source of white light should give 10 candles per watt, and a monochromatic yellow-green source nearly 17 candles per watt. A. R.

640. *Luminous Efficiency of an Integral Radiator.* **C. V. Drysdale.** (Journ. de Physique, 8. pp. 197–201, March, 1909.)—The importance of efficient methods of light production makes it of great interest to ascertain the possibilities of a black body as a radiator of light. The author obtains an expression for the energy radiated by the luminous rays by means of Wien's formula. Using also Kurlbaum's value of the radiation constant, and Lummer and Pringsheim's results, a formula is obtained for the luminous efficiency. Curves are drawn to illustrate the formulæ. At 1,500° C. the efficiency is only of the order of 1 per cent., and at 2,000° C. it is still only about 8 per cent. At 4,000° C. the efficiency would be 80 per cent., and at 6,000° C. about 50 per cent. To obtain high efficiencies, therefore, we must utilise substances showing selective radiation. It is interesting to notice that the temperature giving the max. efficiency is in the neighbourhood of the temperature of the sun as determined by Féry. This coincidence seems to be the result of natural selection. The retina of the eye in those who survive is generally more sensitive to the solar rays possessing maximum energy. A. R.

641. *Polarisation of Light by Internal Diffusion.* **G. Dimmer.** (Akad. Wiss. Wien, Sitz. Ber. 117. 2a. pp. 913–924, July, 1908.)—From Rayleigh's theory it follows that when ordinary light is incident on a turbid medium, the scattered light is completely polarised for all directions perpendicular to the incident light, and partially polarised for other directions. In the experiments described, in which the region of diffusion from 10° to 80° is investigated, the measurements were made by means of a goniometer-polariscope, the material being glasses of various kinds. The percentage, P, of polarised to incident light is determined for different angles, β, of diffusion, and the results plotted and compared with those given by Rayleigh's expression, $P = (1 - \cos^2\beta)/(1 + \cos^2\beta)$. All the experimental curves lie below the theoretical one; this is ascribed to the assumption in the theory of an infinitely small turbidity of the medium. For some of the curves a maximum of polarisation was found with an angle of diffusion of 70°. [See also Abstracts Nos. 2026 (1907), and 594 (1908).] G. E. A.

642. *Absorption Spectra of* p-*Benzoquinone, Quinol, and Quinhydrone in the State of Vapour and in Solution.* **W. N. Hartley** and **A. G. G. Leonard.** (Chem. Soc., Journ. 95. pp. 34–52, Jan., 1909.)—The absorption spectra of *p*-benzoquinone in the form of vapour [see Abstract No. 66 (1909)] and in solution in dry ether have been obtained. When dissolved in alcohol or water, *p*-benzoquinone is reduced by sunlight or ultra-violet rays, giving quinol, so that these solvents cannot be employed. A reversible reaction occurs according to the following equation: $C_6H_4(OH)_2 \rightleftarrows C_6H_4O_2 + H_2$, when *p*-benzoquinone vapour is heated in air at 147° under ordinary pressure. T. H. P.

643. *The Reversal of the Green Mercury Radiation.* **A. Perot.** (Comptes Rendus, 148. pp. 404–406, Feb. 15, 1909.)—The Hg green ray ($\lambda = 5461$) as emitted by the arc lamp was examined in an interference apparatus consisting of a 10-mm. *étalon*, and it was found on looking at the tube end-on that the principal component was asymmetrically reversed. The breadth of the reversal increases with the pressure and at the same time is displaced towards the red. E. C. C. B.

644. *Decay of Phosphorescence at Low Temperatures.* **J. de Kowalski.** (Comptes Rendus, 148. pp. 280–282, Feb. 1, 1909.)—Alcoholic solutions of benzene and its derivatives exhibit, at the temperature of liquid air, a phosphorescent emission characterised by a spectrum of a single band extending, for transparent substances, from the extreme violet of the visible spectrum more or less towards the red. With substances which absorb a part of the visible spectrum, such as the nitroanilines, the emission is, of course, limited by this absorption. By means of screens which cut off any desired portions of the spectra, it is found that the emissions of long wave-lengths diminish in intensity more rapidly than those of short wave-lengths. These results serve to accentuate the difference between the luminous emission produced by luminescence and that caused simply by rise of temperature. In the latter case, when the total luminous intensity diminishes, the emissions of shortest wave-lengths disappear along with those of longest wave-lengths, according to Wien's law. [See Abstract No. 619 (1908).] T. H. P.

645. *Penetrating Radiation from the Earth.* **D. Pacini.** (Accad. Lincei, Atti, 18. pp. 123–129, Feb. 7, 1909.)—Determinations of the ionisation of air contained in a closed zinc vessel, exposed in the open country at Sestola during 24 hours, show it to have a double period daily, reaching a first maximum between 2 and 8 a.m., and a second between 9 and 10 a.m., the minima occurring between 7 and 8 a.m. and noon and 1 p.m. The greatest number of ions produced per $cm.^3/sec.$ was 80, and the lowest 6·8, values of 8, 9, 10, and 12 being also obtained. No connection exists between the ionisation in the vessel and the pressure, temperature, and humidity of the atmosphere, but simultaneous observations of the ionisation in the open air by means of Ebert's apparatus, show that when this reaches a maximum the radiation has a minimum, the latter varying analogously with the value of $Q = I_+/I_-$. The variation in the ionisation of air in the closed vessel appears to be due to the sun, its terrestrial origin being negatived by the wide differences observed. [See Abstracts Nos. 1097 (1906), 651 (1907), and 414 and 684 (1908).] W. H. Sı.

646. *Radio-activity of Rubidium.* **N. Campbell.** (Cambridge Phil. Soc., Proc. 15. pp. 11–12, Feb. 23, 1909.)—In a former paper [Abstract No. 1852 (1907)] the author and A. Wood stated that rubidium and potassium are found to be radio-active, and that the rays from the former metal are less penetrating than those from the latter. Owing to the difference in the penetrating powers of the rays, the relative activity of the two metals cannot be determined directly by a comparison of the total ionisation caused by the rays from a thick layer, but it can be determined by measurements of the activity of layers of varying thicknesses. Such measurements are made with rubidium sulphate. The experimental points obtained by using different masses of salt lie less closely on a theoretical exponential curve than the

corresponding points for potassium; the rubidium rays are probably less homogeneous. It also appears that for infinitely thick layers containing the same proportion of the active metal, the activity is slightly greater for potassium than for rubidium, although the intrinsic activity of the latter is at least 7 times as great as that of the former. On account of the great difference in the penetrating powers of the rays from rubidium and potassium, the activities of these elements cannot be attributed to a common constituent.
A. E. G.

647. *Sub-standards of Radio-activity.* **C. E. S. Phillips.** (Röntgen Soc., Journ. 5. pp. 27–28; Discussion, pp. 29–32, March, 1909.)—A description of three sub-standards of radio-activity prepared for the Röntgen Society. In order to be able to handle the small amount of $RaBr_2$ more easily, a quantity of powdered silica is coated with it. The method of doing this is explained. For the containing vessel several plans are tried; the best appears to be that in which the prepared silica is sealed into a soda-glass bulb. The three sub-standards contain between them about 0·5 mgm. of $RaBr_2$. The actual comparison of these tubes with the standard kept at Victoria University, Manchester, will be undertaken when they have reached radio-active equilibrium.
A. E. G.

648. *γ-Rays of Uranium.* **F. Soddy** and **A. S. Russell.** (Nature, 80. pp. 7–8, March 4, 1909.)—Eve found that uranium gives out only about 1/10 as much γ-radiation as Th when examined through 0·64 cm. of Pb, and this although it gives about 6 times more β-radiation. He also gave the value 1·4 or $\lambda(\text{cm.})^{-1}$ for thicknesses of Pb between 0·28 and 0·92 cm. He stated that the radiation was homogeneous; that the absorption was exponential over this range; and that the rays were practically completely absorbed by 1 cm. of Pb. He worked with uranyl nitrate. The present experiments are carried out by means of UrX obtained in the form of films weighing only a few mgm. UrX contributes all the β- and γ-rays of uranium. The γ-rays are found to decay at the same rate as the β-rays, namely, to half in 22 days. From data given, allowing for the decay during the process of separation, it is provisionally estimated that the ratio of radiation of Ur to that of Ra is about 1 to 500 million, when absorption is eliminated and only γ-rays are dealt with. λ for γ-rays is accurately determined for 14 substances, and it is found that the absorption follows a strictly exponential law after a certain initial thickness of substance has been penetrated, and λ is very nearly proportional to the density of the substance. The value of λ for Pb of thicknesses 1 to 5 cm. is 0·62, while λ/d, where d = density, is about 0·055, as compared with 0·021 for γ-rays of Ra for thicknesses greater than 2·8 cm. of Pb (Wigger). The value for $\lambda/d(0·055)$ is obtained also for Hg, Al, slate, and pinewood, but it does not appear to hold strictly for brass, Zn, Cu, and Sn. The value obtained for λ appears to depend in some unexplained manner on the conditions of experiment, although the exponential law holds quite strictly. Not only is this value obtained for λ different from that obtained by Eve, but for thicknesses of Pb from 0·28 to 0·92 cm. such as were used by him, the rays are not homogeneous and the exponential law does not hold. There is present in relatively great intensity a very much less penetrating radiation, completely absorbed by 1 cm. of Pb, with a value for λ from 8 to 10 times greater than that of penetrating type. Beyond 5 cm. of Pb and corresponding thicknesses of other metals λ appears to change and become much smaller, indicating the existence of a still more penetrating type of radiation than the γ-rays.
A. E. G.

649. *New Method of collecting Radio-active Decay Products: Thorium D a Short-lived Product of Thorium.* **O. Hahn and L. Meitner.** (Deutsch. Phys. Gesell., Verh. 11. 3. pp. 55–62, Feb. 15, 1909. Chem. Inst. d. Univ., Berlin.)—Miss Brooks found that the collection of radium B on the walls of cylinders on the bottom of which the active deposits of radium are placed was not influenced by electric fields. Experiments in which the active deposits, radium (A + B + C), from 2 mgm. of radium are placed on the bottom of a cylindrical vessel, over which is placed a disc-shaped electrode, are carried out. The potential of the electrode can be varied from −220 volts to +220 volts. With the positive field the activity due to RaB on this electrode is only 0·8 per cent. of that obtained with the negative field. Similar experiments are performed with AcC, and it is found that if the negative field is kept on for 10 min. the activity of the electrode reaches 20 per cent. of the total, and by calculation it is shown that the very most one could expect to collect by this means in that time is only 87 per cent. of the total, hence this method is looked upon as a good one for obtaining pure AcC. Now, ThB in changing to ThC sends out α-particles, so we may expect through a "recoil action" ThC to go to the negative electrode, and its activity can be tested. The active deposit from 0·5 gm. radiothorium is collected, and the activity as measured by α-rays shows a much slower rate of decay than could be expected for ThC. When tested for β-rays it is found that this activity arises from β-rays alone, and also that no α-ray product results from the break-up of the β-radiating substance. A decay curve shows a period of 3·1 min., and it is shown that in this β-ray product a new radio-active substance is present, which substance stands in genitical relation to ThA. This substance must come after thorium (B + C), and is therefore designated ThD. It is known that the β-rays from the active deposits of thorium are of two kinds, one soft and the other very penetrating. Previously the former have been ascribed to ThA, the others to thorium (B + C). In the light of these experiments the latter are now looked upon as a product of ThD. Chemical separation has been carried out, and these results confirmed. The question now arises whether the β-rays can exert a "recoil influence" on the atoms from which they issue, and, if so, whether it may not be possible to collect at a negative electrode the direct decay products of such substances as only send out β-rays. For this purpose RaB is tested, and an activity of the electrode amounting to about 0·1 per cent. of that obtained with substances giving out α-rays is the result. The decay of this activity is found to correspond with that of RaC. Owing to certain irregularities obtained with RaC it is hoped to be able to obtain still further decay products in this series. [See also Abstract No. 474 (1909).] A. E. G.

650. *Radio-active Deposits from Actinium.* **J. C. McLennan.** (Nature, 79. pp. 487–488, Feb. 25, 1909.)—W. T. Kennedy finds a marked similarity in the active deposits obtained on positively and negatively charged electrodes placed within an air-tight vessel and subjected to the influence of the active emanation issuing from a sample of actinium. At high pressures the active deposit appears almost entirely on the negative electrode. As the pressure is decreased the amount on both electrodes increases, and ultimately at certain pressures, which are different for the two electrodes, reaches maximum values. If the pressure is still further decreased the amount received on both electrodes rapidly decreases, and finally approaches equality. At a pressure of ¼ mm. of mercury, which is the lowest used, the deposit on the negative electrode is only 8 per cent. greater in amount than that on the

positive. Owing to the very rapid decrease at low pressures it appears highly probable that if the air were entirely removed both electrodes would fail to show any activity. In one experiment, when the salt is at a distance of 1 cm. from the disc electrodes, a max. activity on the negative electrode is obtained at a pressure of 6·5 cm. of mercury, while the max. on the positive is not obtained until a pressure of 1 cm. is reached. In this case the max. activity of the negative is 2·75 times that of the positive. In all experiments the electrodes were exposed 2 hours before being removed for measurement of the activity. The decay period of the active deposits on both electrodes is found to be approximately 89 min. The experiments as a whole indicate that the ions produced in the gas are the carriers of the active deposit, and that the known differences in the rates of diffusion of positive and negative gaseous ions suffice to explain the differences in the amounts of active deposit obtained on the two electrodes. A. E. G.

651. *Secondary γ-Radiation.* **J. P. V. Madsen.** (Roy. Soc. of South Australia, Trans. Vol. 32. 1908. Phil. Mag. 17. pp. 423–448, March, 1909.)—As a result of the passage of γ-rays through matter, secondary rays of two types make their appearance. In this paper those rays which proceed from the sides at which the original γ-rays enter and emerge from the plate which they penetrate are referred to as "incidence" and "emergence" rays respectively. The secondary radiation consists of β- and γ-rays, the former on both sides of the plates. The incidence β-rays have been investigated in some detail by Kleeman and by Eve [see Abstracts Nos. 62 and 1485 (1908)]. In papers by Bragg and the author [Abstract No. 1445 (1908)] it is shown that most of the experimental results so far obtained with these rays can be very simply explained on the "material" theory, if we suppose that the β-rays are produced directly from the γ-particles, and at the outset move in the direction of the γ-radiation, subsequently undergoing scattering in the ordinary manner of β-rays. The second type of radiation resulting from the primary γ-rays, viz., the secondary γ-rays, has been investigated on the incidence sides of plates of different material by Kleeman and by Eve [see Abstracts Nos. 1096 and 1800 (1908)]. The present paper is regarded as of a preliminary nature. Radium is used as the source of the γ-radiation. Full details of the experimental arrangements and also particulars as to the experiments performed are given; the results may be summarised as follows: (1) The γ-rays of Ra, and possibly of Th, appear to consist of two distinct homogeneous bundles, the value of λ/Δ for the soft set being approximately four times that for the hard. (2) For each set of rays the value of λ/Δ is constant, and practically independent of the nature of the absorbing material with which λ is measured, provided that in the case of the soft rays secondary effects are excluded. (3) Secondary γ-radiation appears on both sides of a plate which is penetrated by a stream of γ-rays. There exists a marked lack of symmetry between the amount of secondary radiation which proceeds from the two sides. (4) A lack of symmetry exists, in the case of some substances, between the quality of the radiation on the two sides. (5) The last results seem difficult to reconcile with a "pulse" theory. On the "material" theory propounded by Bragg no such difficulty arises. (6) The secondary γ-radiation appears to be derived from the primary by a process of scattering, this process generally involving a reduction in the subsequent penetrating power of the ray affected. (7) There appears to be reason to believe that the distribution of the scattered radiation depends to some extent upon the hardness of the radiation which is scattered; also upon the nature of the material in which the scattering is produced. The softer radiation appears to be turned back to a somewhat greater extent than the hard. Materials of high atomic weight seem to be able to produce more complete scattering than those of lower atomic weight. (8) The absorption of γ-rays which have already passed through a thickness of one substance by screens of a different substance, may not in all cases give a true measure of the absorption of the original radiation which has been effected by the first screens. [See also Abstract No. 469 (1909).] A. E. G.

REFERENCES.

652. *Michelson's Experiment.* **E. Kohl.** (Ann. d. Physik, 28. 2. pp. 259–307, Feb. 4, and 3. p. 662, March 2, 1909.)—An elaborate development of the theory of the classical experiment by Michelson and Morley in which is discussed the possibility of the fringe system being due to diffraction phenomena. The author also feels that a repetition of the experiment is desirable with special regard to some precautions he refers to which arise out of his view of the matter. [See also Abstracts Nos. 1055 (1902), 1288 (1906), and 897 (1907).] E. H. B.

653. *Dispersion of Electric Double-refraction.* **T. H. Havelock.** (Phys. Rev. 28. pp. 136–139, Feb., 1909.)—A discussion, partly mathematical, of the possible or probable mechanism of the phenomena of dispersion in electric double-refraction and in artificial double-refraction and its connection with the ordinary dispersion of the isotropic medium. The experimental results of C. F. Hagenow on carbon disulphide are also compared with the author's formula for dispersion [see Abstracts Nos. 235 and 1780 (1908)]. E. H. B.

654. *Magnetic Separation of Iron and Titanium Lines.* **A. S. King.** (Astrophys. Journ. 29. pp. 76–83, Jan., 1909.)—Tables of lines of iron and titanium which are affected in sun-spot spectra, with the details of their magnetic separation under different conditions as to relation to direction of field. C. P. B.

655. *Radio-activity.* **A. Debierne.** (Rev. Gén. des Sciences, 19. pp. 691 and 730, 1908. Chem. News, 98. pp. 235–236, Nov. 13; 247–249, Nov. 20; 259–261, Nov. 27; 271–273, Dec. 4; 289–291, Dec. 11, and pp. 300–301, Dec. 18, 1908.)—A *résumé* of present knowledge of radio-activity and radio-active transformations. A. D.

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656. *Melting-point of Platinum.* **C. Féry and C. Chéneveau.** (Comptes Rendus, 148. pp. 401–404, Feb. 15, 1909.)—The authors' results vary between the extremes 1,700° and 1,750° C., according as the blow-pipe flame used was oxidising or reducing. 1,690° was given by a horizontal wire fused by means of an electric current, 1,710° by a vertical wire electrically fused, 1,740° by a Méker burner. The optical pyrometer was used, and experiments showed that the law of emissivity of platinum is $I_\lambda = Ae^{-B/\theta}$, where θ is the absolute temperature, giving a hyperbola for the graduation of the pyrometer. F. R.

657. *Explanation of the Negative Coefficient of Expansion of Silver Iodide.* **G. Jones.** (Amer. Chem. Soc., Journ. 31. pp. 191–200, Feb., 1909.)—From Richards' hypothesis of compressible atoms [see Abstracts Nos. 592 and 593 (1909)] it is deduced that changes in the volume of a substance with rise of temperature must be made up of three components: (1) An increase in the intramolecular space, or at least the space between the centres of the molecules, on account of the increased violence of the molecular vibrations; (2) an increase in volume of the molecules due to a decrease in cohesion; (3) a change in volume of the molecules due to a change in the chemical attraction of the atoms for each other. The author shows that the affinity of silver and iodine increases with rise of temperature, so that, according to the above hypothesis, a decrease in volume should result; silver iodide does, indeed, contract when heated. In general, substances with a low coefficient of expansion are stable at high temperatures, and, conversely, substances with a high coefficient are unstable. T. H. P.

658. *Specific Heats of Liquids at Constant Pressure.* **S. Lussana.** (N. Cimento, 16. pp. 456–459, Nov.–Dec., 1908.)—The author has measured the specific heats at constant pressure of mercury, methyl alcohol, and acetone, at different temperatures and pressures. For the two latter, sufficient data are not available to calculate the isobars, but for mercury, by employing Carnazzi's results [Abstract No. 85 (1904)], the following relations have been obtained: At 22·8° C. and a pressure of 100 atmos., $c_p = c_0 + 213 \times 10^{-8}$, and at 110°, $c_p = c_0 - 268 \times 10^{-9}p - 250 \times 10^{-12}p^2$, the specific heat of mercury at 110° diminishing with increase of pressure. With acetone and methyl alcohol, the specific heat at constant pressure, for temperatures above 20°, increases with increase of pressure, in the case of the former rising to a maximum. Below 20°, the specific heat of each diminishes with increase of pressure. W. H. Si.

659. *Luminosity of the Bunsen Flame.* **B. S. Lacy.** (Zeitschr. Phys. Chem. 64. 5. pp. 633–640, Nov. 10, 1908. From the Inst. f. phys. Chemie u. Elektrochemie d. techn. Hochschule, Karlsruhe.)—The author describes experiments the results of which are in agreement with Haber and Richardt's view [Abstract No. 815 (1904)] that the luminosity of the inner zone of the Bunsen flame is a luminescence phenomenon. According to Baur [Kurzer Abriss der Spektroskopie und Kolorimetrie, Leipzig (1907)], however, this luminosity of the inner cone is not due to a temperature-difference, but is explained by the difference in composition of the gases of the explosion zone and the next intermediate zone. In opposition to Baur's results, the author finds that the introduction of methane into a separated Bunsen flame at a point 5 cm. above the summit of the inner cone produces no effect on the luminosity. Just above the tip of the inner cone the gases contain 0·4 per cent. of methane, which, however, is only present in very small proportions at a somewhat higher point. The value of the constant $k = [H_2O][CO]/[CO_2][H_2]$ was found to be 8·6 just above the inner cone and 8·4 for a higher region at a temperature about 800° lower; these numbers agree with one another and with Haber and Richardt's value, 8·7, within the limits of experimental error. The Pt tube used for extracting the gases exerts a catalytic influence, since, when a Pt tube is used for the inner cone and a porcelain tube for the upper, cooler region, the gases from the latter gave the value 2·9–8·0 for k; removal of the Pt tube resulted in a rise in the value of k for the gases from the porcelain tube. T. H. P.

660. *Combustion of Gases without Flame: Conditions of Ignition by Incandescence.* **J. Meunier.** (Comptes Rendus, 148. pp. 292–294, Feb. 1, 1909.)—The author has studied the conditions of incandescence in a heated spiral of Pt-wire placed in the mixture of coal-gas and air issuing from an Auer burner. The incandescence is only maintained in mixtures which are explosive, and varies in intensity with the explosive nature of the mixture. The phenomena observed during the passage from incandescence to explosion and to flame are also related to the composition of the gaseous mixtures. From the results obtained, the author concludes that flameless combustion is a form of intense combustion like explosion or flame, since it gives rise to a regular and continuous production of CO_2 and water-vapour. It differs essentially, however, from the two other forms of combustion in the manner in which the combustion is propagated across the gaseous layers, the latter converging towards the ignition focus, which is the incandescent substance, and the combustion taking place only at the surface of this substance. [See also Abstracts Nos. 945, 1118, 1119 (1908).] T. H. P.

661. *Coefficients of Gas Viscosity.* II. **W. J. Fisher.** (Phys. Rev. 28. pp. 73–106, Feb., 1909.)—In a previous paper [see Abstract No. 1168 (1907)] the author has shown that Sutherland's equation for gas viscosity may be put into the form $\theta = K(\theta^{3/2}/\eta) - C$. In this paper he gives full details of work which he has carried on to determine the viscosity of air and nitrous oxide at temperatures up to 500° C. In both cases the curve between θ and $\theta^{3/2}/\eta$ is a straight line, and the values of the constants C, K for nitrous oxide agree very well with those obtained from v. Obermayer's results. The capillary tubes used were of glass, and the heating was produced by means of an electric furnace supplied from a motor-generator set. Temperatures were measured by means of a Pt-resistance thermometer. W. C. S. P.

REFERENCE.

662. *Radiation from Cerium Oxide.* **M. Foix.** (Comptes Rendus, 148. pp. 92–94, Jan. 11, 1909.)—In some further experiments upon the radiation of CeO_2 in gas mantles the author proves the validity of the formula theoretically arrived at in his previous papers [see Abstracts Nos. 847 and 1861 (1907)]. E. C. C. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

663. *Fundamental Laws of Electrodynamics.* **R. A. Lehfeldt.** (Phil. Mag. 17. pp. 275–280, Feb., 1909. From Trans. of the S. African Assoc. for the Advancement of Science, Grahamstown, 1908.)—In view of the capabilities of the electron theory it is advisable to base the treatment of magnetism upon current electricity instead of "explaining" the latter by means of magnetic shells. Two moving electrons act upon each other with an electrostatic force independent of their state of motion and a magnetic force depending upon their velocities and directions. Both these forces are inversely proportional to the square of their distance apart. It is convenient to regard the magnetic force as produced in two stages. Each electron produces a magnetic field, and that field acts upon the other electron. The two magnetic actions are not necessarily equal and opposite. The force of electrodynamics between current-elements is derived in a simple manner, and the two circuital relations of electrodynamics are obtained by a calculation of the magnetic potential in an axial and an equatorial direction with respect to an elementary circuit. Finally, a simple deduction of electromagnetic induction is given. E. E. F.

664. *Electric Theory of Gravitation.* **J. J. Thomson.** (Cambridge Phil. Soc., Proc. 15. pp. 65–69, Feb. 28, 1909.)—The conception of electrostatic lines of force producing magnetic fields by their motion is advantageously modified by supposing that those due to any given charge radiate out in all directions, without being modified or bent by other charges. Thus, between two slabs endowed with equal surface densities of electrification, positive and negative respectively, a magnetic field is produced if one of the slabs rotates about a line perpendicular to it, but this field does not extend into the space outside since all the lines of force are between the slabs. This conclusion is, however, contrary to the results of experiment. An independent existence of, say, the positive lines of force would meet this difficulty. It might then be supposed that the electrostatic attraction slightly exceeds the repulsion, and also perhaps that the repulsion between negative elementary charges (electrons) is not exactly the same as between positive elementary charges (positive atoms). Denoting the three coefficients involved by α, β, and γ, we should have $[2\gamma - (\alpha + \beta)]/\alpha = 1{\cdot}2 \times 10^{-36}$ to account for gravitation. This would involve a new definition of an unelectrified body, not based upon the absence of force between it and similar bodies, but upon the equality of the number of positive and negative elementary charges contained in it. The weight of a body on this view depends only on the charges of electricity it contains. If we suppose an atom of hydrogen to contain one positive and one negative charge, the weight of an atom of hydrogen would only be twice that of an electron. But its mass is 1,700 times that of an electron, hence the acceleration of an electron under gravity would be 850 times that of an atom of hydrogen, or 850 × 981; if, on the other hand, the atom of hydrogen contained n elementary positive and n elementary negative charges the acceleration of the electron taken separately would be $(1/n)850 \times 981$. In any case, the acceleration of an electron under gravity would be much

greater than the acceleration of ordinary matter. Even the maximum acceleration of the electron on this hypothesis (850 × 981) is beyond the power of known methods, but with further improvements the effect looked for might be detected in slow kathode rays. E. E. F.

665. *International Conference on Electrical Units and Standards.* (Electrician, 62. pp. 23–26, Oct. 16; 59–63, Oct. 23; and Discussion, pp. 101–105, Oct. 30, 1908. Engineering, 86. pp. 519–520, Oct. 16, and pp. 553–554, Oct. 23, 1908.)—Delegates from 24 different countries met in conference at Burlington House from Oct. 12 to Oct. 22, 1908, the main object of the gathering being the establishment of a universal system of electrical standards acceptable to all. The Conference agreed that as heretofore the magnitudes of the fundamental electric units shall be determined on the electromagnetic system of measurement, with reference to the centimetre, the gramme, and the second. The ohm, ampere, and volt were defined in terms of these, as heretofore. As a system of units representing the foregoing and sufficiently near to them to be adopted for the purpose of electrical measurements and as a basis for legislation, the Conference recommends the adoption of international units. The International ohm is defined very much as hitherto, but the procedure to be followed in determining the resistance of a column of mercury is set out in a specification. The International ampere is defined as depositing silver at the rate of 0·00111800 gm. per sec. and the method of measuring currents is specified. The International volt is defined in terms of the two preceding units, but in another schedule it is stated that the Weston normal cell may be employed as a standard of electric pressure and may be taken, provisionally, as having, at a temperature of 20° C., an e.m.f. of 1·0184 int. volts. A specification relating to the Weston normal cell is attached to the Report. The Conference also recommends that the various Governments interested establish a permanent International Commission for Electrical Standards, and, pending its appointment, a committee of 15 to formulate plans, &c., was nominated. The question whether the ampere or the volt should be the second primary unit was fully discussed. America, France, and 2 other countries were in favour of the volt, but 19 countries were in favour of the ampere. Considerable discussion also took place on the definition of the International ampere. Some of the delegates wished the ampere to be defined as the unvarying current depositing silver at the rate of 0·001118 gm. per sec.; other delegates desired 0·00111800, that is, they wished the ampere to be so defined that comparisons could be made within 1 part in 100,000. The delegates from the United States and some others desired the International ampere should agree as closely as possible with the ampere (10^{-1} c.g.s.), and Lippmann proposed that the International ampere should be defined as being equal to the ampere based on the c.g.s. system, but ultimately the silver deposit at the rate of 0·00111800 gm. per sec. was adopted. F. E. S.

666. *Periodicity of Electrical Dispersion.* **V. Conrad.** (Akad. Wiss. Wien, Sitz. Ber. 117. 2a. pp. 1069–1085, July, 1908. From the k.k. Zentralanstalt für Meteorologie u. Geodynamik, Wien.)—In order to test for the existence of a formal connection between electrical dissipation and magnetic phenomena, the author has examined certain data of electrical dissipation for the existence of a periodicity of 26 days. He has persevered in his task in spite of the facts that he recognises that a period of this length is not now accepted with the same assurance as was the case 20 years ago and that he could only use electrical data extending over short periods. The data used consist of observations made several times a day at Kremsmünster by Schwab from Nov. 1, 1903, to Aug. 31, 1904, which have been discussed by Zölss [Abstract No. 1454 (1905)], and daily observations made by Mazelle at Trieste from March 1, 1902, to Nov. 30, 1903 [Abstract No. 1455 (1905)]. The method used in the analysis was that adopted by Hornstein and Liznar in investigations on the 26-day period in magnetic phenomena (Ibid. p. 394, 1887). A period of 25·72 days was found in the data from Kremsmünster and one of 26·51 in those from Trieste. The amplitudes were very small, 4·7 per cent. and 8·1 per cent. of the mean value respectively. R. G. K. L.

667. *Pressure and Electrical Conductivity of the Atmosphere.* **L. Amaduzzi.** (Accad. Lincei, Atti, 18. pp. 55–58, Jan. 17, 1909.)—The results of some experiments lasting over 10 days are exhibited in the form of curves. One curve is for barometric height and the other for electrical conductivity of the atmosphere. The maxima of electrical conductivity follow the minima of pressure in all cases by a few hours, and the minima of conductivity similarly follow the maxima of pressure. This supports Ebert's contention that the conductivity of the atmosphere is largely due to a radio-active emanation which diffuses out from the soil and through cracks in the earth, on account of variations in atmospheric pressure. S. G. S.

668. *Comparison of Electrometer Records from Neighbouring Stations.* **K. Kähler.** (Meteorolog. Zeitschr. 25. pp. 155–162, April; 289–299, July, 1908, and 26. pp. 10–17, Jan., 1909. From the Meteorolog. Magnetischen Observat., Potsdam.)—Benndorf electrometers have been established at three stations, in connection with the meteorological-magnetic observatory at Potsdam, situated (A) on the tower of the observatory, (B) in a field near the observatory at a distance of about 100 m. from the first station, (C) at a station 1,308 m. distant from the observatory, bearing E. 10° N. from the latter. The present papers are devoted in the main to a comparison of the rapid oscillations shown on the records from the three stations. The traces from stations A and B are practically identical in the vast majority of cases, and as a general rule the curves from C are in such close agreement with those from A and B that there can be no doubt that the various maxima and minima are due to the same causes. The author proceeds to discuss the oscillations in the curves associated with different types of meteorological conditions. (1) Rainfall. The oscillations due to rainfall show a high degree of similarity at the three stations. Close comparison of the time scales reveals the fact that there is in many instances a shift of time scale at C as compared with A and B, and the amount of this shift is found to be closely related with the cloud drift and, in a lesser degree, with the wind. For 32 cases of cloud drift from the west there was a mean lag at C, as compared with A and B, of 3·9 min., corresponding with a velocity of propagation of 5 m./sec. and a mean observed wind velocity of 6·6 m./sec. In four cases of cloud drift from east, A and B lagged behind C by a mean amount of 5·4 min., the mean wind velocity being 5 m./sec. In two cases of cloud drift from north the oscillations were simultaneous, and in three cases of drift from between south and SSW., C lagged behind A by only 1 min. In a number of cases in which the cloud drift could not be determined the electrical effect appears to travel with the wind, but in others this is not so. In most of the latter, however, the wind changed shortly after the observations were made, and the direction of cloud motion as determined subsequently was in agreement with the direction of propagation of the electrical phenomena. In only one case was the direction of clouds and wind definitely opposed to the latter. (2) Snow. The oscillations associated with snowfall are generally in the positive direction, and the similarity between the curves from the three stations is not so marked. Nevertheless it is possible to trace a distinct connection between the cloud drift and the propagation of the electric disturbances. (3) Thunderstorms. A close connection can again be established, but it is remarkable that the lag is in many instances much greater—frequently twice as great—than with oscillations due to rain or snow. It is also noteworthy that on many occasions A and B showed violent fluctuations an hour or so before C was affected, or *vice versâ*. (4) Wind. The effects of wind are very various. Squalls, unaccompanied by rain or thunder, give rise sometimes to positive and sometimes to negative oscillations of potential. The same characteristic lag is observed, indicating a close connection between cloud drift and electrical effects. The effects of strong, steady winds, with snow lying or accompanied by dust-storms, are also discussed. (5) Clouds. Stratus clouds give rise to very marked electrical oscillations, but it frequently occurs that the oscillations at C differ considerably in character from those at A and B. For 44 occasions when the curves were similar, a close connection could be established between the cloud drift and the propagation of the electric disturbances. Cumulus clouds involve an even smaller degree of similarity between the records from the three stations, but still a number of cases of agreement are on record. For cirrus clouds no similarity could be detected. [The contents of the first two parts of this paper have been briefly referred to in Abstracts Nos. 1160, 1851 (1908).] R. G. K. L.

669. *Atmospheric Electricity.* **A. Daunderer.** (Phys. Zeitschr. 10. pp. 113–118, Feb. 15, 1909. Abstract from Dissertation, Techn. Hochschule, München, 1908.)—A continuation of the author's previous work [see Abstract No. 1059 (1907)], in which values were obtained for the density ρ of the electricity in the lower layers of the atmosphere. The yearly and daily variation of the density are dealt with at some length, and it is found that the yearly density curve follows fairly well the temperature, but not the humidity. With rising temperature ρ is much higher than with falling temperature. From his results the author finds that under normal conditions the current downwards to the earth is $4{\cdot}34 \times 10^{-16}$ amp./cm.^{2}. A greater number of measurements has given slightly different values for the mean summer and winter densities to those given in the earlier paper. In the summer $\rho = 0{\cdot}600$ and in the winter $\rho = -0{\cdot}475$; the mean summer value being obtained from 2,041 observations and the winter one from 940 observations. A. W.

670. *Rays of great penetrating Power in the Atmosphere.* **T. Wulf.** (Phys. Zeitschr. 10. pp. 152–157, March 1, 1909. Physikal. Inst. des Ignat.-Coll., Valkenburg, Jan., 1909.)—Describes a continuation of the experiments made by Gockel and the author (Ibid. 9. p. 907, 1908). A daily variation of the γ-rays in the atmosphere is shown to exist, there being usually in the winter months two maxima (8–9 morning and evening) and two minima (after midday and after midnight). Experiments were made all through the winter months, and the effect of various types of weather is dealt with. A. W.

671. *Ionisation of Atmosphere over the Mediterranean Sea.* **G. Costanzo.** (Phys. Zeitschr. 10. pp. 197–199, March 15, 1909. From the Italian.)—

Observations of the loss of charge of an Al-leaf electroscope were made on board ship in different places in the Mediterranean Sea. Difficulties were encountered due to the motion of the ship. The ionisation varied from place to place, being influenced by clouds, temperature, and barometric pressure. The author attributes the greater part of the ionisation over the Mediterranean to the emanation and products of radium, &c., blown over the sea from the land. [See also Abstract No. 1025 (1906).] **A. W.**

672. *Ionisation in the Atmosphere.* **A. S. Eve.** (Nature, 80. pp. 36–37, March 11, 1909.)—The measurement of the atmospheric positive and negative charges by Ebert's apparatus usually indicates an excess of positive over negative of about 20 per cent. So the ratio of the charges has an average value not far different from the ratio of the mobilities of the ions. The following simple experiments by Bates and the author apparently show that Ebert's apparatus, and others of like type, are misleading in indicating a large excess of positive over negative electricity in the atmosphere. A large hollow cone of cardboard was placed so that the air during its passage through the cone to the testing vessel was strongly ionised by the β- and γ-rays of radium, or by the γ-rays alone. The instrument itself was well screened from the rays, and the radium was carefully sealed in a test-tube so that no emanation escaped. The position of the radium was varied so that the number of ions detected in different experiments covered a wide range. In every case the number of positive was greater than the number of negative ions, the mean ratio of the numbers being 1·89; so that whilst the γ-rays of radium produce equal quantities of positive and negative electricity when they ionise gas in a closed vessel, they appear to give a large excess of positive electricity when ionising air near Ebert's apparatus. Since negative ions are under almost all conditions more mobile than positive ions, it would be expected that the negative ions would be captured more readily than the positive in the testing vessel, unless some of the positive ions have a double charge. The recent work of Townsend proves that this may be so, two negative ions appearing at the formation of such doubly charged positive ions. Hence it is possible that in the atmosphere a newly generated positive ion may for a short time be the more mobile, and the apparent excess of positive electricity may not improbably be traced to this cause, as some preliminary experiments seem to indicate. Even if that is so, the fact remains that the quantities of positive and negative electricity in the atmosphere do not differ, at least not to the large extent usually recorded. **A. W.**

DISCHARGE AND OSCILLATIONS.

673. *Photo-electric Effects with Alkali Metals.* **E. Müller.** (Deutsch. Phys. Gesell., Verh. 11. 8. pp. 72–86, Feb. 15, 1909.)—J. J. Thomson has found [Abstract No. 2245 (1905)] that rubidium and sodium-potassium alloy give out negative electrons, if their surfaces are clean, when no trace of light falls upon them. This he explains by assuming the alkali metals to be radioactive. Lenard offers the explanation that the action may be due to invisible ultra-red rays which fall on the metals. In Thomson's experiments the electroscope was not absolutely screened from electrostatical effects, and so great care is taken in the present experiments to obtain an instrument which shall be free from this defect, and at the same time capable of being used in a very high vacuum. A complete description with diagrams of such an electroscopic arrangement for use with sodium-potassium alloy is given, but for this the original paper must be consulted. The experiments with this instrument confirm the statement that a positive charge disappears from the electroscope in the dark. It is found that the effect diminishes with the time, on account of changes in the metallic surface. Experiments on the effect of ultra-red rays are described; for measuring these a sensitive Dolezalek electrometer is employed. Ultra-red rays increase the effect. By absorption experiments, in which water, glass, &c., are tested, the conclusion is arrived at that the most effective rays are either the extreme red of the visible spectrum or the neighbouring ultra-red. Other facts given seem to show that the initial velocity of the electrons emitted by the alkali metals under these conditions is many times greater than that of the electrons emitted by other metals such as Pt, Cu, and Zn. A. E. G.

674. *Magnetic Rays.* **A. Righi.** (Accad. Lincei, Atti, 17. pp. 675–681, Dec. 20, 1908.)—Without furnishing a complete mathematical proof, the author gives reasons for believing that the presence of a magnetic field contributes to the stability of the combinations of ions with revolving electrons which probably constitute "magnetic rays" [see Abstract No. 952 (1908)]. Such combinations are subject to perturbations from other particles. If such a particle approaches the combination and exerts a force upon the electron equal to that exerted by the ion, the electron would ordinarily shoot off at a tangent. The magnetic field normal to its orbit will preserve the curvature of its trajectory and facilitate its retention by the ion. Moreover, though the speed of the electron is not modified by the magnetic field, the radius of curvature of its orbit is diminished, and this favours the stability of the combination. Parabolic and even hyperbolic orbits may be converted into elliptical orbits, and new combinations are thus encouraged. E. E. F.

675. *Doppler-effect in Positive Rays.* **J. Trowbridge.** (Amer. Journ. Sci. 27. pp. 245–249, March, 1909.)—It is now recognised that, in addition to the positive rays behind the kathode (canal rays), there also exist retrograde positive rays which are directed from the kathode towards the anode [see Abstracts Nos. 298 (1907) and 1462 (1908)]. The Doppler-effect should then be found also between the anode and the kathode. In experiments to test this, a tube is used in which the perforated kathode is in a wide tube XY (internal diam. 8 cm.) placed at right angles to the length of the tube and nearer Y than X. At the end X, and perpendicular to the tube XY, is a narrow side-arm ending in a small bulb, which contains the anode. The Rowland grating gave, in the order of the spectrum employed, 6 Å.U. to 0·9 mm. The effect was observed with respect to the hydrogen line 4861·5, and the change in refrangibility was measured by comparison with the solar spectrum, which was photographed immediately beneath the gaseous line without changing the jaws of the slit. The p.d. between anode and kathode varied from 5,000 to 10,000 volts, and the current from 5 to 10 milliamps. With unperforated kathode, and the slit placed at X, no Doppler-effect is seen; when the kathode is perforated the effect is very evident, and indicates a movement towards X which is equal in amount to that observed in the canal region towards Y. Observations are confined to the hydrogen line 4861·5, and photographs show, when the light is observed at X, a line on each side of the ordinary stationary line. Thus there is evidently a movement towards the anode, and also a movement away from it at the kathode.

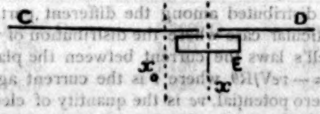
When the slit of the spectroscope is placed obliquely to the band of light the companion line of the stationary line, which indicates a movement away in each case, from the slit, is not visible. The effect takes place at the orifices. The positive particles jostling through the orifices, and mutually repellant, transmit movements (like those resulting from elastic particles in impact) in opposite directions, and those driven in the direction of the anode meet others coming towards the kathode. There results a maximum of radiation of greater refrangibility, which is separated from the refrangibility of the stationary hydrogen line by a less luminous space. The canal rays are produced immediately in front of the kathode, *i.e.*, on the side facing the anode, or in the orifices. In all discharge tubes striæ are seen opposite to the edge of the kathode on the glass; these striæ can be localised to a definite point by bringing the edge of the kathode near the wall of the tube. The heating and oxidising effect from the positive particles of these striæ is very marked, especially when the canal region is small, and is much greater than any effect produced by canal rays in a possible rebounding from the end of the canal region. Photographs are given showing the Doppler-effect and the heating effect of the positive rays. The approximate interval between the Doppler-effect on both sides of the stationary line is 3 Å.U., the distance from X to the kathode being 6 cm. A. E. G.

676. *Mass of the Negative Ion in Flames.* **G. Moreau.** (Comptes Rendus, 148. pp. 842–844, Feb. 8, 1909.)—Two flames, F_1 and F_2, burning vertically, are in contact with and on opposite sides of a fine-meshed Pt-gauze A. In the flame F_2 is placed a particle of a sodium salt, which furnishes both negative and positive ions. The negative ions diffuse through A into the flame F_1. An electric field is established in this flame between a piece of Pt-foil B and the gauze A. From the current I due to the negative ions received by B, the velocity of motion, K, and the molecular velocity, u, of these ions can be found. If N is the density of negative ions in the flame F_2 near A, V the p.d. between B and A, which are separated by distance d, v the vertical velocity of the gases in the flame F_1, S and H the surface and height of the electrode B, e the charge on an ion, then $\omega = vd^2/Hk$, $A = 4/Neu$, $B = d/Nek$, $y = V/I$, $Sy = V(AV + B)/(V - \omega)$; ω being small with respect to B/A, y passes a minimum for a potential $V_0 = \sqrt{(d^2vu/4HK^2)}$. For large values of V, $Sy = AV + B$. The observations of V_0 and y give, by the aid of the above equations, the values of K and u as functions of v, which latter quantity can be measured. From these experiments it is found that for flames at 2,000° absolute K = 1,170 cm. per volt per sec., and $u = 2{\cdot}5 \times 10^6$ cm. per sec., and these values are correct to 1/10. Making use of the equation $mu^2 = 2 \propto T$, m is found to be a mass $1{\cdot}1 \times 10^{-25}$ gm., thus smaller than the accepted mass of the atom of hydrogen, but less than the mass of a corpuscle. That the ion has a mass smaller than that of the smallest atom is explained by assuming the negative ion to be free from encumbrances during part of its course, and therefore the mass and velocity measured must only be looked upon as mean values. A. E. G.

677. *Charges on Ions produced by Radium.* **C. E. Haselfoot.** (Roy. Soc., Proc. Ser. A. 82. pp. 18–22, Feb. 16, 1909.)—Townsend has described a method for the direct determination of Ne [see Abstract No. 518 (1909)], and in his experiments with Röntgen rays he found $1{\cdot}23 \times 10^{10}$ as the value for that quantity in the case of the negative ions. The value obtained by him for positive ions was in some instances $2{\cdot}4 \times 10^{10}$, in others with less pene-

trating secondary rays $1{\cdot}26 \times 10^{10}$. Thus it would appear that the positive ions have in some cases a single, and in others a double atomic charge, whereas the charge on the negative ions is always the same. The present experiments were undertaken to test the theory for ions produced by Ra, the apparatus used being similar in principle to that used by Townsend. The most accurate results can be obtained at pressures of from 4 to 6 mm. and with forces of 1·5 to 2 volts per cm. Thus for positive ions under these conditions it is found that $Ne = 1{\cdot}26 \times 10^{10}$ and for negative ions $Ne = 1{\cdot}24 \times 10^{10}$. As in the case of ions produced by Röntgen rays, it is found that negative ions produced by Ra do not obey the simple laws of diffusion when the air is very dry. This appears from the fact that the ratio R does not vary with the force Z as given by the theory, and that it depends on the pressure. As the drying proceeds the departure of R from the value given by the curve (assuming $Ne = 1{\cdot}28 \times 10^{10}$) is most marked with large values of Z and small pressures. A further point of interest is the fact that it is found easier to experiment with negative than with positive ions. So far the results obtained are in satisfactory agreement with those obtained by Townsend, but up to the present no evidence has presented itself of positive ions with double atomic charges. It is quite uncertain which of the rays of Ra had the predominating effect in the production of the ions examined, though probably the greater number were due to the α-rays. **A. E. G.**

678. *Kinetic Energy of the Ions emitted by Hot Bodies.* **O. W. Richardson.** (Phil. Mag. 16. pp. 890–916, Dec., 1908.)—It has been shown by the author and F. C. Brown how the magnitude and mode of distribution of that portion of the translational kinetic energy of the ions emitted by hot bodies which depends on their velocity component perpendicular to the surface at which they originate, may be measured [see Abstract No. 1825 (1908)]. The part of the kinetic energy which depends on the component of velocity of the ions parallel to the emitting surface may be investigated by experiments of a different character, and these are described in the present paper. An arrangement is considered which consists of an infinitely long, narrow strip of hot metal which almost fills a narrow gap in an infinite conducting plane B. A is a section of the strip. At a short distance from B and parallel to it is another infinite conducting plane CD divided into two portions by a narrow slit parallel to the edges of A. A and B are charged to the same potential and the resulting current to the plane CD is measured. Simultaneously the ions which pass through the slit are measured by means of the box-shaped electrode E. The whole system CED can be pushed along bodily by a fine screw, and the current through the slit is compared with the sum of the currents to the plates CD and the slit, for a series of positions of the latter. In this way a curve is obtained which gives the fraction of the total current



passing through the slit in any position. The curve has a form somewhat resembling that of a sine curve, whereas if the emitted ions possessed no sideways velocity the curve would consist of one horizontal and two inclined straight lines whose directions form a comparatively acute angle. It follows that the ions are emitted with a finite sideways velocity. The dependence of the form of these curves on the distribution of velocity among the ions is next considered, and the mathematical investigation leads to various equations, which are tested by four different experimental methods. The investigations described taken in conjunction with the previous work of Richardson and Brown (which refers to the kinetic energy of the negative ions depending on the normal component of the velocity), and with certain unpublished observations of Brown (which indicate that the + ions obey the same laws in this respect as the negative ions), show that the ions emitted by hot Pt, whether positive or negative, are kinetically identical with the molecules of a gas, of equal molecular weight, at the temperature of the metal. This identity is true not only of the average velocity, but of its mode of distribution among the different ions or molecules. Thus the evidence is completed which shows that the free electrons *inside* the metal have the same amount and distribution of kinetic energy and velocity as the molecules of a gas of equal molecular weight at the temperature of the metal. Moreover, the number and distribution of velocity of the electrons emitted by the metal are the same for all practical purposes, under the conditions of the experiments, as in the steady state. The truth of Maxwell's classical theorems relating to the distribution of velocity amongst a collection of material particles in statistical equilibrium has thus been proved by direct experiment. J. J. S.

679. *Kinetic Energy of Positive Ions emitted by Hot Platinum.* **F. C. Brown.** (Phil. Mag. 17. pp. 355–361, March, 1909.)—The object of the paper is to set forth an investigation into the magnitude and mode of distribution of the kinetic energy of the positive ions emitted by hot platinum. The method of investigation is the same as that used by Richardson and the author for the negative ions [see Abstract No. 1825 (1908)]. It consists in measuring the charging up of a plate opposite a parallel plate containing a strip of the hot metal, both plates being initially at zero potential. The ions from the hot metal cause the opposite plate to acquire a positive potential tending to stop further charging up. From the rate at which the current varies with the potential, both the mean value of the kinetic energy and the way in which it is distributed among the different particles can be determined. In the particular case where the distribution of velocity among the ions follows Maxwell's laws the current between the plates is given by the equation: $\log_e i/i_0 = -veV/R\theta$, where i is the current against a potential V, i_0 is the current at zero potential, ve is the quantity of electricity required to liberate ½ c.cm. of hydrogen in a water voltameter at 0° C. and 760 mm. pressure, θ is the absolute temp., and R is the constant in equation $pv = R\theta$ taken for unit volume of gas under standard conditions. The observations are taken before the Pt-strip has been heated 2 hours, and the temperature [1,067°–1,298° abs.] is kept considerably lower than the corresponding temperatures in connection with the negative ions. The highest potential to which the upper plate is charged by the positive ions is about 0·5 volt, and it is shown that there can be no negative ionisation when that plate is so charged. Three series of experiments are taken, and the experimental value of the gas-constant is found to be $R = 8{\cdot}5 \times 10^3$, while the value of that constant calculated for the same number of particles as those for which R is

given is 8·7 × 10^{3}. It also appears from the table given that the mean kinetic energy is practically independent of the air pressure surrounding the hot Pt. The close agreement between the value of the kinetic energy, and that required for thermal equilibrium would appear to militate against the somewhat prevalent idea that the positive ions arise from chemical action. In that case we should expect the kinetic energy of the emitted ions to be increased by the heat of reaction. [See also preceding Abstract.]

A. E. G.

680. *Effect of Hydrogen on the Discharge of Negative Electricity from Hot Platinum.* **H. A. Wilson.** (Roy. Soc., Proc. Ser. A. 82. pp. 71–72, Feb. 16, 1909.)—In a recent paper [see Abstract No. 1285 (1908)] the author gave a calculation of the thickness of the double layer on the surface, and of the number of free electrons inside the Pt. O. W. Richardson has pointed out that two terms in one of the equations, one of which is discarded as being small compared with the other, are really of the same order of magnitude. The results of the calculation are consequently wrong, and the estimate of the number of free electrons is considerably too high. The difficulty mentioned in the paper, that the energy required to raise the temperature of the electrons is apparently greater than that needed to heat up the Pt, consequently disappears. The number (n) of free electrons per c.cm. of Pt is now found to be $n = 2 \times 10^{22}$, and the values for the thickness (t) of the double layer range between 10·7 × 10^{-8} cm. and 5·6 × 10^{-8} cm.

A. E. G.

681. *The Discharge of Electricity from Glowing Carbon.* **J. A. Pollock** and **A. B. B. Ranclaud.** (Phil. Mag. 17. pp. 866–874, March, 1909. Paper read before the Roy. Soc. of New South Wales.)—The experiments were undertaken in connection with an investigation of the phenomena associated with the relighting of the carbon arc. The critical voltages at which the non-luminous discharge between the carbons changes into the luminous discharge are given in the following table:—

Distance between Carbons.	Temperature.		Critical Voltage for Arcing.	Current just before Arcing in Milliamps.
	Hot Carbon.	Cool Carbon.		
1 mm.	1,800° C.	1,860° C.	48·5	2·87
1 "	1,680	1,240	55·0	2·50
1 "	1,550	1,100	68·5	2·66
1 "	1,415	920	88·0	2·82
2 "	1,800	1,120	58·0	1·85
2 "	1,680	980	66·0	1·95
2 "	1,550	860	81·0	2·07
2 "	1,415	650	97·0	2·20
8 "	2,060	1,070	89·5	0·97
8 "	1,800	880	70·0	1·12
8 "	1,680	750	85·0	1·20

If I be the current of negative ions, E the potential gradient at the anode surface, and λ the length of the last free run of the ions at the end of which they reach the anode surface, it is suggested that arcing commences when $IE\lambda$ attains a value sufficient to raise a part of the anode surface to such a temperature that positive ions are somewhat freely emitted. A. R.

682. *Note on the Electron Theory of the Carbon Arc.* **J. A. Pollock.** (Phil. Mag. 17. pp. 361–366, March, 1909. Paper read before the Electrical Assoc. of New South Wales.)—The application to the case of the arc of the idea of the projection of electrons from the surface of incandescent carbon leads to the following general description of the distribution of potential between the carbons: (1) A forward e.m.f. at the kathode surface. (2) A back e.m.f. at the surface of the anode depending on the temperature of the crater. (3) An anode fall of potential equal to the back e.m.f. at the anode. (4) A kathode fall of potential which when added to (1) gives a critical value. This description agrees with the facts discovered by Duddell. The magnitudes of the above e.m.f.'s are independent of the current and the arc length. If we add together the e.m.f.'s (1), (2), and (3), and subtract (4), we get what has been called the back e.m.f. of the arc. In the case considered it is 88·8 volts. With the figures given the velocities of the electrons are as follows: At projection from anode, $2·5 \times 10^8$ cm. per sec. At projection from kathode, $1·5 \times 10^8$ cm. per sec. At collision at end of kathode fall of potential, $2·6 \times 10^8$ cm. per sec. At collision with anode surface, possibly $8·6 \times 10^8$ cm. per sec. A. R.

683. *Thermal Effects of the Duddell Arc: Probable Fusion of the Carbon.* **M. La Rosa.** (Comptes Rendus, 148. pp. 475–478, Feb. 22, 1909.)—In a previous paper [see Abstract No. 697 (1907)] the author has shown that a Duddell arc sometimes occurs with a condenser only between the carbons. In this case there is an increase in both the frequency and the amplitude of the oscillations, and the mean power expended in each discharge is much greater. The spectrum of the arc also presents striking peculiarities. This suggested to the author that it was at a much higher temperature, and so he attempted to fuse "sugar" carbon. When acted on by the Duddell arc, shunted by 60 mfd. for some hours, growths form on the electrodes, the one on the positive carbon being larger and of a different shape from the one on the negative. Examining by a microscope the powder obtained in this way, little grains of transformed carbon were detected, quite different from the ordinary graphite. The experiments lead to the conclusion that the particles of transformed carbon met with in the Duddell arc have been liquefied, and this is a proof that its temperature is much higher than the ordinary arc. (Ibid. pp. 616–617, March 8, 1909.)—The author now announces that he has succeeded in separating from sugar carbon submitted to electrical action in the Duddell arc grains which sink in bromoform and in iodide of methylene. Most of the grains are more or less rounded, have a grey colour, and are very brilliant. When examined with a microscope it is seen that they are undoubtedly crystalline. Triangular and trapezoidal facets have been noticed. These crystals will scratch rubies. The largest particle yet obtained has a max. length of 1·8 mm. It is very transparent and its surface is striated. When a quantity of these have been obtained the author will make a chemical examination of them. A. R.

684. *The Mercury Vapour Lamp as Rectifier.* **J. Sahulka.** (Elektrotechn. Zeitschr. 29. pp. 1036–1037, Oct. 22, 1908.)—A brief account of experiments made in 1894 by the author. The chief feature is that the direction

of the rectified current of the arc in air (Fe or C as electrode against Hg) was opposite to the direction in the Cooper-Hewitt rectifier. This behaviour is explained as being due to the difference in conductivity of the surrounding medium in the two cases. L. H. W.

685. *Selective Effect in the Ionisation of an Alternating Electric Field.* **H. A. Perkins.** (Comptes Rendus, 148. pp. 398–401, Feb. 15, 1909.)—The author has previously described a curious effect produced when a vacuum tube is subjected to an alternating electric stress [see Abstract No. 1186 (1908)]. He now describes further researches with the same apparatus, but with the tube connected with a mercury pump, so that the pressure in it could be varied. The ring [*loc. cit.*] being at a pressure of 2,000 volts alternating from earth and being round a certain part of the tube, a current flows through the rarefied air when the pressure is 0·5 cm. of Hg. The region where the ring exerts this effect is very narrow, but the more the pressure of the air is reduced the more this region widens. When the current flows the tube is always luminous. At the start the deflections are very variable, but between the pressures 0·05 and 0·01 cm. the results were regular, and he found the same effects as in his previous experiment. At the moment, however, when striations appear the deflections become irregular. Many reversals of current are obtained during the passage of the ring from one end to the other of the tube. The zero points correspond to sudden changes in the appearance of the striations. After the pressure is reduced to 0·02 cm. the positive column has almost disappeared. The discharge is visible, however, owing to the fluorescence of the gas under the action of the electrons put in motion by the electrostatic field. But the direction of the current has now reversed—that is to say, the pole nearest the ring is negative from the point of view of the external circuit. The current increases when the ring begins to move from one end of the tube to the other. It has its max. value when it has passed over one-third the length of the tube and is zero at the middle. It then goes through similar values over the remaining half. At this very low pressure the phenomena are very regular and can always be repeated. This appears to show that the effect of the electrostatic charges on the surface of the glass now only play an unimportant *rôle* in the phenomenon. To study the phenomena produced at pressures of 0·001 cm. and less the author used an induction coil with an ordinary magnetic interrupter. But even under these unfavourable conditions the phenomena could be repeated. In order to explain the effect it has to be remembered that at pressures of 0·002 cm. the mean free path of the electrons is comparatively large, and ions are produced by shock. Instead also of the ionisation being limited to the ends of the tube, as in the first experiment, ionisation will be taking place all along the tube. This is due to the ions moving under the applied p.d. between the ring and the tube. The coefficient of diffusion of the negative ions through the metal is greater than that of the positive ions. This difference is large at ordinary pressures, but it must be much greater at very low pressures when the greater part of the negative charge is carried by the electrons themselves. Making certain assumptions an equation is then obtained for the current, the form of the current curve as the ring passes from one end to the other of the tube being assumed to be known. A. R.

686. *Electric Discharges in Intense Magnetic Fields.* **Gouy.** (Comptes Rendus, 148. pp. 455–458, Feb. 22, 1909.)—Experiments are performed to show the effect of strong magnetic fields upon discharges in rarefied air.

An electrical machine is used giving 0·0006 amp., and the magnetic field is varied from 2,000 to 4,000 gauss. It appears that the rays, called by Villard magneto-kathode rays, can be produced even in a perfectly uniform magnetic field—a point worth noting, since the proposed explanations of the phenomena do not apply in such cases. When only those magneto-kathode rays which come directly from the kathode are present the following phenomena appear: (*a*) If the tube has two kathodes in metallic connection each produces a magneto-kathode beam of rays uninfluenced by the other; but if the beams are made to coincide the part between the kathodes is brightly illuminated, whilst that part between the kathodes and the walls of the tube is rendered much less bright. At the same time the dark space near the kathode is much reduced on the inter-kathodic side, the bright light nearly touching the kathode. In very low vacua this reduction may or may not take place. (*b*) When the anode is quite free from all magneto-kathodic rays, and placed in a sufficiently large space, a luminous crown is seen around it, the middle of which is dark, the dimensions increasing with the degree of the vacuum. This crown is circular with very small anode, and its plane is normal to the field. If the anode is slightly elongated the crown is oval, and its plane is normal when the anode itself is perpendicular to the lines of force. If the anode is parallel to the field the crown takes the form of a sheath enveloping the whole length of the anode; this crown presents a most singular structure. The anode is a wire perpendicular to the lines of force, protected by a glass tube until within 10–15 mm. of its end. This glass tube naturally interrupts the crown, but in this part, and on one side only, it appears as a luminous helix, of which may be distinguished 5 or 6 slightly flattened turns. The helix changes side when the field is reversed. (*c*) When an intense magneto-kathode ray is led across the magneto-anodic crown, quite close to the anode in the dark space, the crown disappears completely. If the rays meet the anode without going by its edge, the crown persists but is slightly diminished. (*d*) When this crown is present a considerable fall of potential occurs in the neighbourhood of the anode, which increases with the degree of the vacuum, attaining 8,000 volts with a tube which is equivalent to a 4-mm. spark in the absence of the field. This fall becomes quite insignificant when the crown is made to disappear by the action of magneto-kathode rays. On the other hand, the kathode-fall is diminished by the field, so that usually the field diminishes the voltage required by the tube, since the anode-fall is more than compensated by the diminution in the kathode-fall. A. E. G.

687. *Electrocapillary Actions and Discharge in Rarefied Gases.* **G. Reboul.** (Comptes Rendus, 148. pp. 617–618, March 8, 1909.)—In the rarefied gas round a drop of mercury positive and negative charges are formed. A simple experimental method of showing this is described. The electrodes consist of a nickel plate and a drop of mercury at the end of a capillary tube. When the disruptive voltage is attained there is a lag of some minutes until the discharge occurs, but when the mercury is made to flow the discharge takes place at once, whether the mercury be the kathode or the anode; the formation of the drops, therefore, gives to the gas the ions necessary to start the discharge. When the p.d. is less than the disruptive potential by 10 or 20 volts the discharge starts when the mercury begins to flow, if the mercury be negative. But if the mercury be positive there is no discharge. To explain these results we must remember the difference in the mobility of the positive and negative ions. The latter being the first to move can produce by their collisions discharge in cases where the collisions of the positive ions have no effect. It is equally probable that the variation of the surface of the drop diminishes the contact p.d. between the mercury and the air, and so facilitates the discharge. Remembering the order in which the electricities occur in the double layer, this only happens when the mercury is negative. This last effect is manifested strongly at low pressures. When the pressures are of the order of the hundredth of a millimetre we have a kathode discharge plainly shown up by the luminescence of the gas and the phosphorescence of the walls. In this case if we make the mercury flow we see round the drop a dark cone which weakens the light and the phosphorescence of the walls in its path. A. R.

688. *Momentum Effects in Electric Discharge.* **F. E. Nipher.** (Science, 29. pp. 287–288, Feb. 5, 1909.)—Additional details as to shadow photographs by pierced rubber sheets and glass fibres [see Abstract No. 271 (1909)], the fogging being apparently traceable to momentum effects of the electrons at the right angle of a wire carrying a discharge. E. H. B.

689. *New Phenomenon in Electric Discharge.* **F. E. Nipher.** (Science, 29. p. 384, March 5, 1909.)—A platinum wire 0·05 mm. diam. after carrying a non-oscillatory discharge during three weeks of use was found to have formed along its whole length a system of wavelets of wave-length 0·9 mm. and double amplitude 0·15 mm. E. H. B.

690. *Behaviour of Barretters and other Thermo-indicators with Currents of different Frequencies.* **J. Rautenkrantz.** (Phys. Zeitschr. 9. pp. 911–915, Dec. 15, 1908.)—The first part of the paper is concerned with the proportionality of the indications of barretters. Undamped oscillations of frequency 8,000 per sec. from a Tesla apparatus and also slightly damped oscillations of order 10^6 per sec. were employed. Two barretters having wire diameters of 0·00525 and 0·00815 mm. respectively were compared. At the lower frequency there was complete proportionality throughout. At the higher frequency the proportionality held down to 85 scale divisions, corresponding to a galvanometer current of about $52{\cdot}5 \times 10^{-8}$ amp.; above this point the proportionality was complete. The value of the most favourable bridge current is found to be independent of the frequency. The second part deals with the question of proportionality in the thermo-indicators of the types due to Klemenčič and to Brandes. It is found that with those instruments of this type which have the same "sensibility factor" for alternating as for direct current (viz., $i/\sqrt{\alpha} =$ a const., where i is the current and α the deflection) practically identical readings are obtained with direct current, alternating current, or oscillations. L. H. W.

691. *Hertzian Waves and Fredholm's Equation.* **H. Poincaré.** (Comptes Rendus, 148. pp. 449–453, Feb. 22, 1909.)—The author shows by means of Maxwell's equations how all problems in connection with the propagation of Hertzian waves simplify down to finding integrals of a Fredholm's equation. In Maxwell's notation this equation is written—

$$2\pi\mu = \int \mu' \partial\sigma' [\cos\psi\, (\epsilon^{-\omega r}/r)\, (\omega + 1/r) - \omega^2 L] + N,$$

where N is a known function. In the case of spheres and cylinders, that is in the practical cases, the calculation of L presents little difficulty. This equation solved in Fredholm's manner enables us to discuss the problem of the reception of Hertzian waves, ω and N being assumed known, and also the emission of Hertzian waves, N now being zero and ω unknown. Theoretically the above equation is the solution of the problem of diffraction. The magnitude of the value of ω, however, introduces practical difficulties which require special investigation. A. R.

692. *Electromagnetic Waves on Wires with Insulating Covering.* **H. Weiss.** (Ann. d. Physik, 28. 3. pp. 651–661, March 2, 1909. Extract of Dissertation, Würzburg.)—The object of the research is to test the theory developed mathematically for this case by Harms [see Abstract No. 1184 (1907)]. In the theory the case of a single wire far from all other conductors is considered, but in the experiments two wires 28 cm. apart are used. Drude's arrangement is employed [see Phys. Soc. Abstracts, No. 788 (1895)]; but instead of a bridge at the further end of the wires a large metal plate outside the dielectric and small metal plates in the dielectric are used to reflect the waves. The dielectrics employed are water, benzol, ether, and aniline; these are contained in glass tubes in which the wires are stretched centrally. The theory is confirmed in every respect. Finally the glass tubes are coated with tin-foil, so that the dielectric is contained in a metal tube, and the outside reflecting metal plate is fixed where the tin-foil begins. The little metal plates inside the glass tubes are moved, and it is found that the waves penetrate so far that 4 or 5 nodes can be easily observed. In this way the dielectric constants of water, ether, and aniline are found to be 77, 4·5, and 7·3 respectively, instead of the usual values 81, 4·3, and 7·2. T. P. B.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

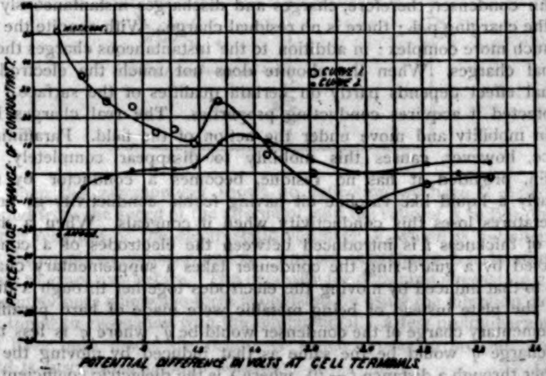
693. *Secondary Current in Selenium Cells.* **A. Pochettino.** (N. Cimento, 16. pp. 381–429, Nov.–Dec., 1908.)—A lengthy investigation of the secondary current induced in a selenium cell by the passage of an electric current through it. Thirty-five cells have been examined, including cells with positive, negative, and no photo-electric effect, and it is concluded that (1) the secondary current is not simply of thermoelectric origin, as shown by measurements with a thermopile and with a bolometer; (2) a secondary current is produced in all cells having a positive photo-electric effect, whatever the material of the electrodes; (3) the secondary current occurs with greater intensity in those cells which at the moment of experiment have greater resistance and well-defined positive photo-electric effect, *i.e.*, where the resistance diminishes with increase of voltage, and the behaviour approximates to that of an electrolyte; (4) if the resistance of a cell is varied the secondary current becomes more marked with increase of resistance; (5) if the primary current is not applied for more than 2 min. the initial intensity of the secondary current increases proportionally with the voltage applied and with the square root of the time of application; and (6) illumination with a Nernst lamp increases the rate of disappearance of the secondary current. [See also Abstract No. 1561 (1907).] W. H. Sı.

694. *Nobili's Figures.* **G. Delvalez.** (Journ. de Physique, 8. pp. 174–180, March, 1909. Paper read before the Soc. franç. de Physique, Dec. 18, 1908.) —Nobili's figures can be formed by immersing a large parasitic electrode in a vessel containing an electrolyte, *e.g.*, a mixture of copper and lead acetates. In front of this and normal to it conducting wires are arranged. A current enters by some of these wires and leaves by the others. Rings are produced first in front of the anodes, and then of the kathodes. These rings progress

quickly at the beginning, then slowly, and soon become fixed. Guébhard has said that these coloured rings approximate very closely to the equipotential lines which the direct application of the electrodes upon the immersed plate would give. The present paper is an inquiry into the truth of this statement. Numerous qualitative experiments, in which Pt-foil, steel needles, drops of mercury are placed in acidulated water, or copper, brass or mercury, in a solution of $CuSO_4$, show that a conducting mass immersed in an electrolyte shunts a part of the current which traverses it. The study of the deformation of equipotential surfaces caused by immersing sheets of a conductor is an undeniable proof of this. The question is investigated experimentally, first by means of a copper sheet in a solution of $CuSO_4$ containing 100 gm. to the litre, then with a sheet of silver placed in the same solution. Lastly, an experiment is made in which a brass sheet is put in Nobili's mixture. This is tried, since brass gives colours under conditions where the other conductors do not. By means of results obtained it is shown that Guébhard's suggestion of equipotential lines, although near the truth, does not hold strictly.

A. E. G.

695. *Photo-active Cells with Fluorescent Electrolytes.* **P. Hodge.** (Phys. Rev. 28. pp. 25–44, Jan., 1909.)—Owing to the conflicting results obtained by different observers for the effect of light on the electrical conductivity of cells containing a fluorescent electrolyte, this effect is remeasured [see Abstract No. 2554 (1904)], chiefly by means of a saturated solution of eosin in alcohol. The resistance of the cell was measured by the Wheatstone bridge, and the conclusion drawn from a number of tests was that, in the first place, no effect is produced by light upon the conductivity of a fluorescent solution unless a region very near the electrodes is illuminated, and that, further, this effect at the electrodes is only produced in a very thin film of the liquid immediately in contact with the surface of the plates [see also Abstract No. 285 (1909)]. The effect at each electrode was next investigated with varying p.d. between the terminals of the cell, and a number of curves (see given curve in Fig.) shows the effect to be different at the two electrodes. On the anode the effect at low voltage is opposite to that on the kathode, and in both cases the effect changes sign as the voltage rises.



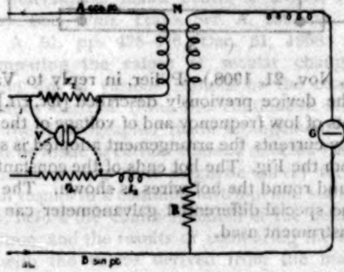
G. E. A.

696. *Electromagnetic Striction.* **P. Bary.** (Journ. de Physique, 8. pp. 190–196, March, 1909.)—Experiment and theory show that the flow of current through a liquid conductor produces in the liquid a variable pressure which is a maximum at the axis, and may attain a high value when the current density is great. The movements of the liquid produced by these forces diminish as the density of the liquid is increased. These phenomena are produced by *electromagnetic striction*, and transform electrical energy directly into mechanical energy. The author first discusses the flow of current through a liquid, and then attempts to deduce some conclusions for the flow of current through a gas. When the current flows in the liquid the power expended is $RC^2 + w$, where w is the energy necessary to maintain the movement of the liquid. It is proved that w varies directly as the fourth power of the intensity of the current. The counter-e.m.f. produced by the movement of the liquid is proportional to the cube of the intensity of the current. The effects of inertia are also considered, and a theory is given of the Wehnelt interrupter. The problem of the conduction through gases is much more complex. In the Duddell arc the note is due to the rupture of the conducting vein of gas due to striction. Hence it acts like a Wehnelt interrupter. It does not seem impossible that air subjected to great striction should attain a velocity of 85 metres per sec. If so, this would serve to explain the counter-e.m.f. of the electric arc. A. R.

697. *Experimental Researches on Dielectrics.* **L. Malclès.** (Ann. Chim. Phys. 16. pp. 158–286, Feb., 1909.)—An account is given of a very complete and thorough experimental research on the properties of dielectrics. The following are some of the author's conclusions: Hard paraffin extracted from ozokerite possesses at ordinary temperatures perfect dielectric stability. A paraffin condenser, therefore, charges and discharges instantaneously whatever the charging p.d.; there is no residual charge. With ebonite the effects are much more complex: in addition to the instantaneous charges there are residual charges. When the ebonite does not touch the electrodes the residual effect depends partly on certain qualities of the surface. When unprotected it acquires conducting properties. The real charges have a certain mobility and move under the action of the field. Paraffining the surface, however, causes this mobility to disappear completely. Hard paraffin, provided it has no residue, becomes a conductor by fusion. Similarly a liquid like vaseline oil having feeble conductivity at ordinary temperatures loses this conductivity when it congeals. When a metallic plate of thickness t is introduced between the electrodes of a condenser protected by a guard-ring, the condenser takes a supplementary charge q, equal to that induced by moving the electrodes together through a distance t. If the plate instead of being metallic were made of hard paraffin, the supplementary charge of the condenser would be q', where q' is less than q. The charge q' would be the same as that induced by moving the plates together through a distance $t - t/\lambda$, where λ is the dielectric coefficient of the paraffin. If the dielectric plate introduced between the electrodes were of ebonite protected by a layer of paraffin in addition to the supplementary charge q' induced instantaneously, there would be a residual charge q_r which increases to a max. value q_m, but $q' + q_m$ is always less than q. If the dielectric were a layer of powder similar effects would be produced, but $q' + q_m$ continually approaches q as the powder is made finer and more homogeneous. If the interposed dielectric be a liquid (not touching the electrodes) the supplementary charge q' added to the residual charge q_m

equals q. If the liquid has a feeble conductivity, it is possible to express q as an exponential function of the time. The author gives two empirical formulæ for the conductivity and the dielectric coefficient. The results for ebonite prove that the hypothesis of an isotropic medium is untenable. We can, however, find an exponential formula for the residual charge on the assumption that it acts like a liquid inside a layer of paraffin. The assumption of the coexistence of conductivity and permittivity in a dielectric layer not in contact with the electrodes is sufficient to explain all the observed phenomena. With hard paraffin the charge depends only on the permittivity. With liquid layers we need to know the conductivity as well. Finally, the phenomena for ebonite can be explained by considering it as a liquid enclosed in a layer of paraffin. [See also Abstract No. 460 (1908).] A. R.

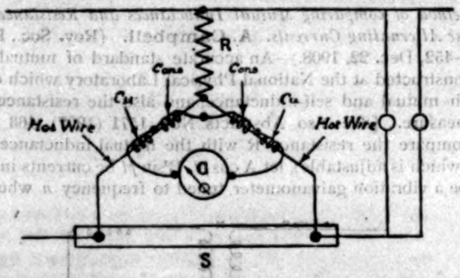
698. *Method of comparing Mutual Inductances and Resistances by the help of Two-phase Alternating Currents.* **A. Campbell.** (Roy. Soc., Proc. Ser. A. 81. pp. 450–452, Dec. 22, 1908.)—An accurate standard of mutual inductance has been constructed at the National Physical Laboratory which can be used to test both mutual and self-inductance, and also the resistance of coils in absolute measure. [See also Abstracts Nos. 1571 (1907), 468 (1908).] In order to compare the resistance R with the mutual inductance M (a small fraction of which is adjustable), let A cos pt, B sin pt be currents in quadrature, and let G be a vibration galvanometer tuned to frequency n where $p = 2\pi n$.



Then, when the galvanometer shows no deflection we have $R = (A/B)pM$. p is found from the speed of the alternator, and the ratio of A to B is obtained from the readings of the electrostatic voltmeter V, which is put alternately across the equal resistances r_1 and r_2. The self-inductance l_2 is to adjust the currents to exact quadrature. The necessity for obtaining alternating current of absolutely pure sine wave-form is obviated by using the vibration galvanometer tuned to resonance with the fundamental. A few preliminary experiments have been made, the results of which appear to indicate that the method is susceptible of high accuracy. W. C. S. P.

699. *Behaviour of Quadrant Electrometers towards Alternating Currents.* **E. Orlich.** (Zeitschr. Instrumentenk. 29. pp. 33–46, Feb., 1909. Communication from the Physikal.-Techn. Reichsanstalt.)—The paper is mainly mathematical, and contains a method for measuring the alternating-current constant of an electrometer for a given phase-difference and wave-form. As a rule the constant so obtained agrees well with that obtained by direct-current measurements. Further, the influence of the capacity of the electrometer is discussed, and calculations are made under various conditions, of the errors due to the resistance of the suspension. Other corrections, such as those necessary when the needle is charged by tapping off between two known potentials, are also investigated. For full particulars the original should be consulted. **W. C. S. P.**

700. *Thermo-wattmeter for High-frequency Currents.* **R. van Cauwenberghe.** (Lumière Électr. 4. pp. 181–182, Oct. 31, 1908. Elect. Rev. and West. Electn. 53. p. 878, Dec. 5, 1908. Abstract.)—The author criticises the device employed by Pillier [see Abstracts No. 1296 (1908)], and describes an arrangement consisting of two Voege thermo-elements connected to a differential galvanometer, which he calls a thermo-wattmeter. **L. Pillier.**



(Ibid. pp. 245–246, Nov. 21, 1908.)—Pillier, in reply to Van Cauwenberghe, points out that the device previously described [*loc. cit.*] was for use with alternating currents of low frequency and of voltage of the order of 100 volts. For high-frequency currents the arrangement adopted is somewhat different, as will be seen from the Fig. The hot ends of the constantan-copper thermo-junctions are wound round the hot wires as shown. The advantage of this method is that the special differential galvanometer can be dispensed with and an ordinary instrument used. L. H. W.

ALTERNATING CURRENTS AND MAGNETISM.

701. *The Composition of Alternating Electromagnetic Fields.* **A. Artom.** (Atti dell' Assoc. Elettr. Ital. 12. pp. 547–569, Sept.–Oct., 1908. Elettricità, Milan, 32. pp. 90–93, Feb. 11; 109–111, Feb. 18, and pp. 122–126, Feb. 25, 1909.)—The paper consists of two sections, the first being the demonstration of the production of a rotating high-frequency magnetic field which causes a type of induction motor to revolve, and an analysis, by means of a Braun's oscillograph, of a rotating electric field. The motor has a squirrel-cage armature of tinfoil on cardboard, which is free to rotate inside a fixed coil of one or two turns carrying the main current. In addition to the fixed coil there is an adjustable field coil which is in series with only a variable condenser. When this latter circuit is properly tuned, and has its coil set at an angle to the fixed field coil, a rotating field is created and the armature revolves. Means were taken to eliminate the electric effects, proving that the rotation was due to the magnetic field alone. The rotating field was examined by means of a Braun's oscillograph, using an ingenious combination of capacities and inductances for varying the strength of the components. The second section is devoted to a description of an apparatus for the radiation of elliptically polarised electric waves. Two crossed aerials are used, in which the currents are in different phases. Both are excited by the same spark circuit, but the coupling is in one case electric and the other magnetic. J. E.-M.

702. *Magnetic Properties of the Rare Earths.* **S. Meyer.** (Akad. Wiss. Wien, Sitz. Ber. 117. 2a. pp. 995–1000, July, 1908. From the II. Physikal. Inst. d. k.k. Univ., Wien.)—The values of the molecular magnetic susceptibilities $\times 10^6$, of the oxides of Welsbach's elements, aldebaranium, and cassiopeium [see Abstract No. 1422 (1908)] are for Ad_2O_3, 18·8 ; Cp_2O_3, 8·78. Hence for Ad, 9·15 ; Cp, 1·9. It is inferred that the atomic volume of Ad is less than that of Cp. The spectra of the rare earths are discussed. Mixtures of metallic powders of yttrium and erbium, and erbium with holmium, were not much more magnetic than the oxides, but showed distinct remanence. The pyrophoric cerium-iron and lanthanum-iron alloys are also only feebly magnetic. It is not yet proved to be impossible to obtain highly magnetic alloys from the metals of this group ; if alloys of high density can be made it is to be expected, from the relation of susceptibility and atomic volume, that they will be strongly magnetic. F. R.

703. *Magnetic Observations round Coasts of British Isles.* **L. W. P. Chetwynd.** (Roy. Soc., Phil. Trans. Ser. A. 209. pp. 227–248, Jan. 25, 1909. Proc., Ser. A. 81. pp. 475–476, Dec. 31, 1908. Abstract.)—With the object of comparing the values of secular change of declination, horizontal force, and dip at various stations on the coasts of the British Isles, with the values derived from the continuous records obtained at Kew Observatory, the Hydrographer made arrangements that during 1907 observations should be made at certain stations selected from those occupied by Rücker and Thorpe during their magnetic survey for the epoch Jan. 1, 1891. To reduce all results to a common instrumental standard, observations were made at Kew, before the commencement of the field observations and after their completion, and the results of comparing the values obtained by each instrument with the values derived from the magnetograms were applied as corrections for instrumental differences, thus reducing the field observations to the Kew instrumental standard. The stations chosen were Harwich, Great Grimsby, Sunderland, Stonehaven, Kirkwall, Dublin, Tanera Mor, Weymouth, Milford Haven, Stranraer, Letterkenny, and Loch Melfort ; abstracts of the results are given for each in the same form as that adopted by Rücker and Thorpe. The resulting mean annual changes in the magnetic elements are then tabulated, and a detailed discussion given of the comparative secular changes at different stations, illustrated by curves of mean annual changes. In several cases the declination values at sea were compared with the neighbouring shore values by "swinging ship," it being found that, in general, East Coast sea values were greater, and West Coast sea values less, than the corresponding land values. C. P. B.

REFERENCES.

704. *Earth-inductors.* **J. J. Taudin Chabot.** (Phil. Mag. 16. pp. 916–918, Dec., 1908.)—Description of a modified form of rotating earth-inductor previously described [see Abstract No. 569 (1903)] but without sliding contacts. A. D.

705. *Impulsive Motion of an Electrified Sphere.* **G. F. C. Searle.** (Phil. Mag. 17. pp. 44–71, Jan., 1909.)—Mathematical. [See Abstract No. 488 (1907).]

706. *Electron Theory.* **L. Silberstein.** (Ann. d. Physik, 28. 2. pp. 308–312, Feb. 4, 1909.)—Chiefly occupied with a discussion as to the distribution of the charge of an electron, three cases being considered: the uniform density charge, the pure surface charge, and finally a central nucleus with a density equal in every radial direction and asymtoting to zero with infinite distance. [See Abstract No. 1694 (1908).] E. H. B.

707. *Electric Units.* **Brylinsky.** (Soc. Int. Élect., Bull. 9. pp. 9–20; Discussion, pp. 20–34, Jan., 1909. Rev. Électrique, 11. pp. 29–31, Jan. 15, 1909. Abstract.)—Chiefly with reference to the findings of the International Conference [see Abstract No. 665 (1909)]. **D. Berthelot.** (Soc. Int. Élect., Bull. 9. pp. 57–77; Discussion, pp. 77–78, Feb., 1909.)

708. *Imaginaries applied to Oscillations.* **F. Emde.** (Elektrotechnik u. Maschinenbau, 27. pp. 79–83, Jan. 24, and pp. 111–115, Jan. 31, 1909.)—A mathematical article dealing with the application of complex quantities to the solution of the differential equations of the phenomena of electrical oscillations. J. D. C.

709. *Glass of Low Resistivity.* **C. E. S. Phillips.** (Roy. Soc. Edinburgh, Proc. 28. pp. 627–642, 1907–1908.)—Further particulars are given as to the preparation and properties of the glass dealt with in Abstracts Nos. 324 (1907) and 409 (1908). L. H. W.

710. *Apparatus for measuring Radio-activity by the Electroscopic Method.* **C. Chéneveau** and **A. Laborde.** (Soc. Franç. Phys., Bull. 8. pp. 262–275, 1908. Journ. de Physique, 8. pp. 161–174, March, 1909.)—A detailed description of an electroscope and appliances of a very compact form suitable for testing the radio-activities of solids, liquids, and gases is given. The apparatus is standardised and a full account follows as to the method of doing this. A. E. G.

711. *Mercury Interrupters with Different Gases as Dielectrics.* **Béclère.** (Archives d'Él. Médicale, 16. pp. 856–864, Oct. 25, 1908.)—The experimental results of an investigation, using a glass-walled interrupter in which the gases nitrogen, CO_2, ammonia, acetylene, and hydrogen were substituted for the now generally used coal-gas, are set forth in a table which gives information as to the appearance of the spark at secondary, the condition of the mercury after prolonged use, and the nature of the spark at the break. L. H. W.

712. *A New Decimal Resistance Box.* **A. Bombe.** (Elekt. Runds. 26. pp. 106–107, March 13, 1909.)—The box contains coils of resistances 1, 3, 3, 2 ohms respectively, and any resistance from 0 to 9 ohms is obtained by short-circuiting one or more of the coils. The number of coils is also reduced to a minimum, as also is the error due to variation in the plug contact resistance. W. C. S. P.

713. *Reducing the Exposure required in Radiography.* **J. Bergonié** and **E. Spéder.** (Archives d'Él. Médicale, 16. pp. 941–950, Nov. 25, 1908. Paper read before the Assoc. franç. pour l'Avancement des Sciences, 1908.)—The investigation is solely concerned with the d'Arsonval-Gaiffe X-ray equipment, which is fully described. A table is given showing the current (milliamps.) through the tube with different groupings of the condensers and for different equivalent spark-lengths. L. H. W.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

714. *Instability of Radium Bromide.* **W. Ramsay.** (Akad. Wiss. Wien, Sitz. Ber. 117. 2a. pp. 943–946, July, 1908. Communication from the Radium-Kommission d. Kaiserl. Akad. der Wissenschaften.)—A specimen of radium bromide weighing 0·5 gm. is found after a time to be reduced in weight to 0·388 gm. These experiments are carried out in order to find the cause of this decrease in weight. A weighed specimen is compared as regards activity, with a weighed quantity of pure radium chloride. For this purpose the discharging effects of β- and γ-rays are used. Then both the specimens used are treated with pure hydrobromic acid until their weights are constant. Calculations based on the results of these experiments show that 0·388 gm. of the salt are equivalent to 0·4971 gm. $RaBr_2 2H_2O$. Other experiments indicate that the original salt must, in the two years since its preparation, have been changed into carbonate. When the original salt is treated with water the gas collected consists mainly of oxygen with comparatively small quantities of CO_2, hydrogen, nitrogen, and helium. A. E. G.

715. *True Atomic Weight of Silver.* **G. D. Hinrichs.** (Comptes Rendus, 147. pp. 1802–1808, Dec. 14, 1908.)—The author refers to the work of L. Dubreuil (Ibid. pp. 1800–1802), who, like himself, regards 108 as the true atomic weight of silver. In 15 out of the 23 processes employed by Stas for determining the atomic weight of silver, the deviations from 108 are less than 20/1000. Greater deviations from 108 have been found by using the nitrate of silver, but these may possibly be due to a small proportion of occluded oxygen and oxides of nitrogen. T. H. P.

716. *Atomic Weights of Iodine and Silver.* **G. P. Baxter** and **G. S. Tilley.** (Amer. Chem. Soc., Journ. 31. pp. 201–221, Feb., 1909. Contribution from the Chem. Lab. of Harvard College.)—The authors give a method for preparing pure iodic acid, and confirm the existence of the compound, I_2O_5, HIO_3. The density of iodine pentoxide at 25°/4° is 4·80. Using a hydrazine salt for reducing iodic acid and precipitating the iodine as silver iodide, the ratio of silver to iodine pentoxide is found to be 0·646230. On this basis, if $O = 16$, the atomic weight of silver is 107·850, and that of iodine 126·891. T. H. P.

717. *Density of Methane: Atomic Weight of Carbon.* **G. Baume** and **F. L. Perrot.** (Comptes Rendus, 148. pp. 39–42, Jan. 4, 1909.)—A number of determinations give the mean value 0·7168 gm. for the weight of a litre of methane under normal conditions. This result gives for the atomic weight of carbon values varying from 12·003 to 12·005 according to the different physico-chemical methods of atomic weight calculation. Liquid methane has a density varying from 0·477 to about 0·466 between the melting- (−184°) and boiling-points (−164°). T. H. P.

718. *Heat of Oxidation of Tin.* **W. G. Mixter.** (Amer. Journ. Sci. 27. pp. 229–234, March, 1909. Contribution from the Sheffield Chem. Lab. of Yale Univ.)—Describes new determinations of the heat of oxidation of tin in the form of finely-divided metal obtained from sodium-tin alloy, and in the

form of pure tin-foil; of the heat of oxidation of stannous oxide, and also the heat of combustion of tin with sodium peroxide. The following are the results:—

$Sn + O_2 = SnO_2$ (crystalline)	+ 137,200 cals.
Sn (crystalline) + O = SnO (crystalline)	+ 66,200 „
SnO (crystalline) + O = SnO_2 (crystalline)	+ 71,000 „
SnO_2 (amorphous) = SnO_2 (crystalline)	+ 1,700 „
$2Na_2O_2 + Sn = Na_2SnO_3 + Na_2O$	+ 133,800 „
$2Na_2O + 2O = 2Na_2O_2$	+ 38,800 „
$Na_2O + Sn + 2O = Na_2SnO_3$	+ 172,600 „
$Na_2O + SnO_2$ (crystalline) = Na_2SnO_3	+ 35,400 „
$Na_2O + SnO_2$ (amorphous) = Na_2SnO_3	+ 37,100 „

C. O. B.

719. *Phosphides of Zinc.* **P. Jolibois.** (Comptes Rendus, 147. pp. 801–803, Nov. 2, 1908.)—Two phosphides of zinc may be prepared by direct combination of phosphorus and zinc, Zn_3P_2 and ZnP_2. The former is obtained by pouring fused zinc on to red phosphorus and heating the mixture in an earthen crucible until no more phosphorus vapour is evolved, after which the phosphide is separated from excess of zinc by either volatilising the latter *in vacuo* at 600° C., or by dissolving it in mercury. The phosphide has the sp. gr. 4·55 at 18°, and on treatment with concentrated or dilute HCl is completely decomposed, with evolution of pure H_3P. ZnP_2 is formed when Zn_3P_2 is subjected to the action of phosphorus vapour *in vacuo* at 400° C.; it is a black, non-crystalline powder, having the density 2·97 at 15°. W. H. St.

720. *Tin Phosphides.* **P. Jolibois.** (Comptes Rendus, 148. pp. 636–638, March 8, 1909.)—Crystalline Sn_4P_3 has been prepared in silvery-white spangles having a density at 0° of 5·18, and decomposing at 480°. No compounds corresponding to Sn_5P_2, Sn_2P, Sn_3P_2, SnP or SnP_2 could be isolated, but by heating pure Sn with red phosphorus in sealed Jena glass tubes in an electric furnace up to 620° for 10 hours, and extracting the alloy successively with HCl, warm dilute caustic soda, and HNO_3 (sp. gr. 1·2) diluted with its own volume of water at 50°, a crystalline phosphide SnP_3 is obtained, resembling silicon in colour, having a density at 0° of 4·10, and dissociating at 415° into P and Sn_4P_3. W. H. St.

721. *Absorption of Hydrogen by Nickel.* **A. Sieverts** and **J. Hagenacker.** (Ber. Deut. Chem. Gesell. 42. p. 2, 1909. Chem. News, 99. p. 132, March 18, 1909.)—Numerous experiments confirm Sieverts' and Beckmann's conclusion that Ni absorbs from 0·25 to 0·5 volumes of hydrogen, between 377° and 580°, although Mayer and Altmayer state that much larger quantities are absorbed. At 822° and 923° the absorption is nearly proportional to the square root of the pressure. F. R.

722. *Action of CO on Cr, Ni, Mn, and their Oxides and Alloys.* **G. Charpy.** (Comptes Rendus, 148. pp. 560–561, March 1, 1909.)—The experiments were conducted at 1,000° C. Carbon dioxide has practically no action on Ni, a very slight cementation being alone observed. Oxide of nickel is completely reduced. Mn and ferro-manganese absorb CO, and again give it off. Protoxide and carbon are formed. Mn_3O_4 heated in CO is converted into protoxide. Cr heated in CO gives the sesquioxide, mixed with carbon. CO

carburises the iron whilst oxidising the Cr in chrome or chrome-nickel steel. A small proportion of CO_2 is liberated, provided Cr does not exceed 7 per cent. If the steel is in masses the oxidation of the Cr only occurs superficially.
F. R.

723. *Occluded Gases in Metals.* **B. Delachanal.** (Comptes Rendus, 148. pp. 561–564, March 1, 1909.)—The following table resumes the results of experiments in which the gases given off upon heating metals in a porcelain retort were estimated :—

Metal.	Weight of Metal in gm.	Cm.³ of Gas Evolved.				
		Hydrogen.	Carbon Monoxide.	Carbon Dioxide.	Methane.	Nitrogen
Aluminium	200	88	0	—	—	—
Magnesium I.......	20	12	4·1	—	—	—
Magnesium II. ...	40	35·06	2·44	—	—	—
Zinc	100	18·15	1·65	0·50	—	—
Tin	1,000	3·25	2·05	1·94	2·80	1·56
Platinum	144	0·47	4·05	0·70	3·67	1·31
Iridio-platinum I.	146	3·65	3·60	0·60	0·87	1·08
Iridio-platinum II.	150	2·64	3·19	0·51	0·31	0·55

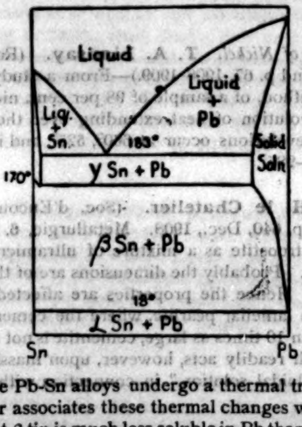
150 gm. of spongy Pt evolved 17 cm.³ of gas whose presence appeared to be entirely due to incomplete washing of the sample. Methane is probably not occluded, but formed by the action of H on CO. This research was initiated by J. B. Dumas.
F. R.

724. *Recalescence of Nickel.* **T. A. Lindsay.** (Roy. Soc. Edinburgh, Proc. 29. pp. 57–61, and p. 67, 1908–1909.)—From a study of cooling curves, by the differential method, of a sample of 98 per cent. nickel, from 900° C. to 180° C., a gradual evolution of heat extending over the range 700°–285° is found. More rapid evolutions occur at 660°, 525°, and important evolutions at 440°–370° and 370°–285°.
F. R.

725. *Troostite.* **H. le Chatelier.** (Soc. d'Encouragement, Rev. de Métallurgie, Mém. 5. p. 640, Dec., 1908. Metallurgie, 6. p. 97, Feb., 1909.)—The author regards troostite as a mixture of ultramicroscopic particles of cementite and ferrite. Probably the dimensions are of the order of less than a millionth of 1 mm. Hence the properties are affected by surface tension. For example, even in lamellar pearlite, where the cementite lamellæ are of the order of more than 10 times as large, cementite is not attacked by alkaline sodium picrate, which readily acts, however, upon massive cementite. The use of the term "colloidal solution" in connection with troostite is strongly disfavoured.
F. R.

726. *Function of Chromium and Tungsten in High-speed Tool Steels.* **C. A. Edwards.** (Iron and Steel Inst., Journ. 77. pp. 104–132, 1908. Mech. Eng. 21. p. 723, June 5, 1908. Abstract.)—The author reaches the conclusion that the function of Cr, in the presence of W and Mo in high-speed steels, is to give to the alloys when cooled from near the melting-point great hardness and increased resistance to tempering. One such alloy, containing C 0·68, Cr 8·01, W 19·87, and Si 0·04 per cent., had when hardened the exceptionally high Brinell hardness-number 866. Cutting tests show that the higher the degree of hardness, compatible with toughness and the same degree of "red-hardness" [see Abstract No. 869 (1907)], the better the cutting efficiency of such tools. After case-hardening, the cutting speeds of steels of this class containing 6 and 8 per cent. Cr respectively, for 20 minutes' life on a ½-in. cut with $\frac{1}{16}$-in. traverse, cutting a 0·6 per cent. carbon steel forging, were increased 18 and 14·5 per cent. respectively. The polyhedric structure of the hardened steels is transformed to martensitic on heating to about 680° C. At 680°–780° a brittle constituent is formed, and it is to the presence of this constituent, and not to loss of hardness proper, that the ultimate failure of the tool is due. A critical range which begins at 880° C. in steels containing over 8 per cent. Cr and 6 per cent. W, cooled from 1,200° is explained as being a critical change in a carbide of tungsten formed at 1,200°. The fact that upon cooling from 1,820° there are no critical points below 900° is due, it is suggested, to the formation, at the higher temperature, of a double carbide of W and Cr. F. R.

727. *Explanation of a Discrepancy concerning the Lead-Tin Alloys.* **W. Guertler.** (Zeitschr. Elektrochem. 15. pp. 125–129, March 1, 1909.)—Using the method of thermal analysis, various workers have shown that lead is capable of retaining about 10 per cent. of tin in solid solution. On the other hand, determinations of electrical properties (conductivities, &c.) by other workers indicate the entire absence of solid solutions, at all events up to a temperature of 150° C. It has previously been shown that, besides the β to α change at 18° C., tin undergoes a slight thermal transformation at 170° C., and that the Pb-Sn alloys undergo a thermal transformation at about 160° C. The author associates these thermal changes with a γ to β change in the tin, assumes that β tin is much less soluble in Pb than γ tin, and on this basis constructs the diagram reproduced in the Fig. The Pb-crystals, as deposited, are saturated with γ tin, which is converted into β tin at the transformation-point. The thermal change is enhanced in magnitude by the rejection of the much less soluble β tin from the solid solution. At low temperatures, therefore, solid solutions no longer exist, and consequently the Pb-Sn alloys



do not deviate from the first law of conductivities. [No mention is made of the work of Rosenhain and Tucker on these alloys. See Abstract No. 822 (1909).] F. C. A. H. L.

728. *Effect of Titanium on Steels.* **C. V. Slocum.** (Electrochem. Ind., N.Y. 7. pp. 128–130, March, 1909. Mech. Eng. 23. pp. 336–337, March 12, 1909. Abstract.)—Describes results obtained by adding ferro-titanium to various classes of steel. The titanium alloy contains 10–15 per cent. Ti, 5–7 per cent. C, less than 0·5 per cent. other impurities, the balance, about 80 per cent., being iron. This alloy is made in the electric furnace. In Bessemer practice the alloy is added after the Mn, while the steel is flowing into the ladle. After this addition the metal is held 8–15 min. before teeming. There is an increase in the amount of slag removed from the metal, which latter lies "dead" in the ingot moulds, and the steel is free from blow-holes. In open-hearth steel the effects of the treatment are freedom from blow-holes and pin-holes, increases in elastic limit, reduction of area, &c. Open-hearth castings from metal treated with the alloy are more blue in colour, free from brittleness, more easily machined and heat less under the tool, hence may be machined more rapidly than other steels of the same carbon content. In the crucible the alloy has been found to increase the strength of Ni and Cr-Ni steels, acting as a powerful deoxidiser. In chilled castings 1 per cent. of the alloy increases the crushing strength nearly 100 per cent., and grey-iron castings from 20–40 per cent. In dies and die blocks the alloy gives great resistance to shock, with consequent increase in life. No reduction of the P and S contents of the steels has been found by the use of the alloy, but it is claimed that by its use the obnoxious effect of these impurities is reduced. On being added to molten iron or steel the Ti unites with the O and N in the metal, increasing its temperature some 30° to 50°. Aluminium must not be used in any case with the Ti alloy, and the proportion of ferro-silicon should be decreased and sometimes entirely eliminated. When dirt specks are found in the surface of the treated steel the amount of ferro-manganese should be increased by about 10 per cent. The percentage of alloy to be used varies with the grade of the iron to be treated and the results desired. Ordinarily 0·1 per cent. Ti is a good proportion. The Ti itself passes off with the slag which it removes, unless excess be added, when this will be found in the steel. C. O. B.

729. *Crystallisation of Steel.* **A. A. Baikoff.** (Ann. de l'Inst. Polytech., St. Pétersbourg, 8. p. 289, 1907. Abstracts in Rev. de Métallurgie, 5. p. 177, 1908. Metallurgie, 6. pp. 103–104, Feb., 1909.)—The following are the author's percentage analyses of large crystal growths found by Tschernoff (Metallographist, 2. pp. 74–75, 1899) and by Żemcżużny in the pipes of large ingots and of smaller ones found by Jacowleff in various ingots—

	C	Mn	Si	S
Tschernoff	0·780	1·055	0·255	—
Żemcżużny	0·542	0·689	—	0·169
Jacowleff	0·978	0·781	—	0·080

The microscope shows that the slag enclosures largely follow crystalline outlines. The equilibrium of the system, iron, manganese, and sulphur, is probably represented by the reversible reaction: $FeS + Mn \rightleftarrows MnS + Fe$, and we have $C/C_1C_2 =$ a constant, where C, C_1, C_2 are respectively the concentrations of MnS, Mn, and FeS. This shows that when the concentration of Mn is below its limit of solubility it does not crystallise. Also in view of the fact that the heat of formation of MnS from FeS is positive it is seen that the formation of MnS is favoured with fall of temperature, and it is probable that it begins to crystallise out after the solidification of the major portion of the metal. F. R.

730. *Thorium.* **R. J. Meyer.** (Zeitschr. Elektrochem. 14. pp. 809–810, Dec. 11, 1908.)—Criticises the conclusions of W. v. Bolton [Abstract No. 157 (1909)]. It is probable that v. Bolton's metallic Th contained an important quantity of oxide. The salt obtained by treatment with HCl may have been the metachloride with the formula ascribed by v. Bolton, but his analyses disagree with the formula considerably. The results are probably better to be explained, however, by admitting that the isomerism of metathoric acid falls in line with that of stannic and zirconic acids. **H. Karstens.** (Ibid. 15. pp. 33–34, Jan. 15, 1909.)—Karstens shows that the thorium chloride used by v. Bolton was pure and free from oxychloride, and that 85 per cent. of the Th present was dissolved in HCl. The case for metathorium chloride of the formula $m(ThO_2)\ x(ThCl_4)$ is contested. m and x are whole numbers. F. R.

731. *Calcium Sulphate and Fluxes at High Temperatures.* **H. O. Hofman** and **W. Mostowitsch.** (Amer. Inst. Mining Engin., Bull. 25. pp. 51–76, Jan., 1909.)—$CaSO_4 + 2H_2O$ loses its combined water at about 900° C., begins to be dissociated in pure air at 1,200° with separation of $SO_2 + O$, and fuses to a variable mixture of CaO and $CaSO_4$ at about 1,360°. Silica decomposes calcium sulphate, the reaction commencing at about 1,000° and being complete at 1,250°, with formation of silicate, $CaSiO_3$, Ca_2SiO_4, &c., at temperatures below their melting-points. Ferric oxide is not dissociated in pure air at 1,500°, but begins to decompose calcium sulphate at 1,100°; the decomposition is complete at 1,250°, and occurs more readily than with silica. Calcium ferrite, $CaOFe_2O_3$, is formed; it fuses at 1,250°, but can dissolve and decompose a further quantity of calcium sulphate, probably forming other ferrites. Pure lead oxide does not decompose calcium sulphate. The results are applied in the discussion of the fluxing actions in the following metallurgical processes: Carmichael-Bradford, ordinary oxidising roasting, oxidising roasting of calcareous blende, reduction of roasted calcareous blende, Knudsen's pyritic smelting, basic steel processes, ferruginous slags in non-ferrous smelting. F. R.

732. *Conductance and Fluidity of Fused Salts.* **H. M. Goodwin** and **H. T. Kalmus.** (Phys. Rev. 27. pp. 322–328, Oct., 1908. Contribution No. 27 from the Research Lab., Mass. Inst. of Technology.)—The authors have determined the densities and molecular volumes of lead chloride, lead bromide, and potassium dichromate over a temperature interval of 100–150°. The equivalent conductivity and equivalent fluidity are calculated from the data of Lorenz and Kalmus [Abstracts Nos. 1271 and 1608 (1907)], and their ratio compared with the similar data given by Goodwin and Mailey [Abstract No. 508 (1908)]. For potassium dichromate this ratio, Λ/f, is found to be nearly constant over a temperature interval of 110°; for lead chloride and bromide it decreases with rise of temperature. From these results and those previously obtained with the alkali and silver nitrates, it appears that the ratio Λ/f for a given salt over a temperature interval of 100–150° above its melting-point either is constant or decreases with rise of temperature. The

increase in conductivity of these salts with rise of temperature may be fully accounted for by the increase in their fluidity. For those salts with which the equivalent fluidity increases more rapidly than the conductivity, it seems probable that the number of carriers decreases with rise of temperature as in the case of other highly dissociated salts in water at high temperatures. The data obtained do not allow of a quantitative determination of the degree of dissociation of fused salts, but they indicate a high rather than a low degree of ionisation. The high conductivity is probably due to a large number of carriers rather than to a high migration velocity. T. H. P.

733. *Latent Heats of Fusion and Specific Heats of Liquid and Solid Salts.* **H. M. Goodwin** and **H. T. Kalmus.** (Phys. Rev. 28. pp. 1–24, Jan., 1909. Contribution No. 28 from the Research Lab., Mass. Inst. of Technology.)—By means of a special apparatus the authors have measured (1) the latent heat of fusion and (2) the specific heats just above and just below the melting-points of KNO_3, $NaNO_3$, $LiNO_3$, $AgNO_3$, $AgCl$, $TlCl$, $PbCl_2$, $AgBr$, $TlBr$, $PbBr_2$, $K_2Cr_2O_7$, and $NaClO_3$. Kopp's law holds for all these substances, but with an atomic heat at the temperatures employed of 7·1 instead of 6·4 for the elements present with the exception of oxygen, for which the atomic heat is 5·9. The specific heat of all the above salts is slightly greater for the liquid than for the solid state. No stoichiometrical relations are apparent between the values of the latent heat of fusion and the molecular, atomic, or crystallographic properties of the salts investigated. The theoretical lowering of the freezing-points of the salts due to the solution of a small quantity of a second salt was calculated from the latent heats of fusion, comparison of the results obtained indicating that the pure fused salt and the dissolved salt are probably both highly dissociated. T. H. P.

734. *Reducing Action of Electrolytic Hydrogen on Arsenious and Arsenic Acids.* **W. Thomson.** (Roy. Soc. Edinburgh, Proc. 29. pp. 84–95, 1908–1909. Chem. News, 99. pp. 157–159, April 2, 1909.)—The reducing action of electrolytic hydrogen upon arsenious and arsenic acids, when liberated from the surfaces of different elements, was studied. Thirteen different elements were tested, viz., Pb, Zn, Cd, Sn, Ag, graphite, Fe, Pt, Al, Au, Co, Ni, and Pd. The results show that lead is the most efficient element examined for removing As, and it liberates AsH_3 from both arsenic and arsenious acid with the same velocity. On the other hand, silver liberates As as AsH_3 from arsenious acid with about the same velocity as lead or zinc, but is powerless to liberate any As when it exists as arsenic acid. From the various experimental results a velocity constant has been calculated by employing the formula for a monomolecular reaction. F. J. B.

735. *Dynamic Allotropy of Sulphur.* I. **H. R. Kruyt.** (Zeitschr. Phys. Chem. 64. 5. pp. 513–561, Nov. 10, 1908. Van't Hoff Laborat., Utrecht, June, 1908.)—The early literature upon this subject is collected and discussed. It is shown that the assumption of dynamic allotropy, by Smith and his pupils, forms a fairly satisfactory explanation of the experimental facts recorded in the literature. On the other hand, it appears that certain deviations observed could be explained by the assumption of a labile region of limited miscibility upon the following grounds: (1) Miscibility by falling temperatures. (2) Form of the equilibrium curve. (3) Independence of the melting-point of the presence of S_μ, when the amount present exceeded 4 per cent. In consequence of this last condition the melting-point curve becomes parallel to the concentration axis from a temperature of 111° C. Doubt is

thrown upon the conclusion that S_λ is present as a solid phase in this system, and the conclusion that S_8 is the formula for S_μ is regarded as uncertain. The melting-point curve for rhombic sulphur with additions of S_μ was determined, and the melting-point of pure rhombic sulphur fixed as 112·8°. The melting-point usually found, viz., 110·5, corresponds to a mixture containing 8·5 per cent. of S_μ. The composition of the vapour was determined between the temperatures 300° and 375° C., and the point of intersection of the curves was found, which gave the composition of the vapour and liquid phases. This point was found to be 324° C. and 24·7 per cent. S_μ. The vapour-pressure curves of the system S_λ—S_μ show either a maximum or a minimum, and these curves cut the equilibrium curve. **F. J. B.**

736. *Determination of the Surface Tension and other Physical Constants of Mixtures of Acetic Acid and Water.* **L. Grunmach.** (Ann. d. Physik, 28. 2. pp. 217–258, Feb. 4, 1909. Extract from Wissenschaft. Abhandl. d. Kais. Normal-Eichungs-Kommission, Berlin.)—The author has determined the surface tension of acetic acid and water mixtures, by the wave method, and finds that the surface tension as well as the values of specific cohesion continuously decrease with increase in the percentage amount of acetic acid, and that the values are not governed by the density of the mixture. Of two mixtures having the same density but different composition, that with the higher percentage of acetic acid has the smaller surface tension and smaller specific cohesion. The author has also determined the viscosity of the mixtures, and finds that the viscosity increases with increase in the concentration of acetic acid up almost to the point of max. contraction, after which it decreases at first slowly but then quickly. In the case of the refractive indices, the maximum point does not coincide with the max. contraction and the max. density. Similarly with regard to the electrical conductivity. The investigation was undertaken in order to find the connection between surface tension and viscosity, but no general connection has been obtained. **A. F.**

737. *Hydrolysis of Salts in Solution: Lecture Experiment.* **B. L. Vanzetti.** (Gazetta Chim. Ital. 38. 2. pp. 98–99, 1908.)—The following simple experiment renders evident the phenomenon of hydrolysis of salts. A test-tube is filled to about three-fourths of its height with a 5 to 10 per cent. gelatine solution containing faintly alkaline phenolphthalein. When the gelatine has solidified a 10 per cent. ferric chloride solution is poured on to it. As diffusion into the gelatine proceeds, two strata become more and more distinct, the lower one being colourless, owing to the more rapid diffusion of the acid liberated by hydrolysis, and the less advanced opaque one consisting of ferric hydroxide. Salts, such as nickel chloride or copper sulphate, containing a coloured ion may also be used. **T. H. P.**

738. *Cohesion Pressure: Theory of Solutions.* **I. Traube.** (Deutsch. Phys. Gesell., Verh. 10. 22. pp. 880–930, Nov. 30, 1908. Techn. Hochschule, Charlottenburg.)—The osmotic and capillary phenomena of solutions exhibit perfectly parallel behaviour. Substances such as inorganic salts, which raise the surface tension of water, do not in general penetrate animal or vegetable cells; whilst those which lower the surface tension of water do penetrate, the ease of penetration increasing with the molecular depression of the surface tension. When any two aqueous solutions are separated by a membrane, the solution with the smaller surface tension, and especially the dissolved

substances which lower the surface tension of the water, tend to diosmose in the direction of the greater surface tension; the direction and velocity of osmosis are also considerably influenced by the adsorptive properties of the membrane.. To the pressure with which the particles of solute cohere to the solvent the author gives the name "cohesion pressure," the molecular cohesion pressure being that exerted by 1 mol. of solute on 1 litre of solution, and being identical with the molecular depression of surface tension of a solution. The cohesion pressure is the intensity factor and the number of particles the capacity factor of solution energy. The sugars, mannite, urea, and glycocoll have approximately equal cohesion pressures, as also have the salts. With aqueous solutions of alcohols, esters, and fatty acids, however, the surface tension differs widely from that of water. A hydrate possesses a smaller cohesion pressure than the free ion or the non-hydrated molecule; the capacity for hydrate-formation increases with increasing cohesion pressure. The solubility of a substance depends on the difference between its cohesion pressure in solution and its internal pressure. When two substances have the same solubility, their internal pressures stand in the same relation as their cohesion pressures. Substances with negative cohesion pressures are diminished or increased in solubility by substances of positive or negative cohesion pressure. When several salts (substances of positive cohesion pressures) are present in solution, the solubility is displaced in favour of the salt with the smallest cohesion pressure. Protein and other colloids of high molecular weight do not influence the surface tension of water, because their cohesion pressure, like that of suspended particles, is zero, or practically zero. The behaviour of peptone and protein shows that, as regards their cohesion pressure, colloids like protein form connecting links between solutions and suspensions. The author has measured for N/4 solutions of a number of organic compounds, (1) the capillary heights, (2) the coefficients of distribution between benzene and water and between animal charcoal and water. The results show that cohesion pressure, distribution coefficient, and adsorption run roughly parallel. Only when the cohesion pressure of the substance in water falls below a certain value does the substance pass into the benzene. When a solution of a substance in benzene or similar organic solvent is brought into contact with water, distribution takes place only if the cohesion pressure of the substance in water is less than a certain limiting value, otherwise the substance passes completely into the water; but if the cohesion pressure in water is zero, the substance remains entirely in the benzene. Of substances with the same boiling-point, the one with the smallest cohesion pressure has the greatest vapour pressure. In general the velocities of the anions increase with the cohesion pressures of the corresponding hydrogen compounds, whilst those of the kathions increase as the cohesion of the corresponding salts diminishes. The greater the cohesion pressure of an anion, in general the greater will be its decomposition voltage. In the series of the anions the specific heats of the substances dissolved in water decrease as the cohesion pressures increase, whilst with the kathions the reverse is the case. The magnitude of the heat of neutralisation depends not only on the degree of ionisation, but also on the difference between the cohesion pressures of the electrolytes. The fact that acetic acid exhibits almost the same heat of neutralisation as the strong acids is explained by the fact that, on account of the smaller cohesion pressure of acetic acid, the work required to separate acetic acid from the solvent is less than the corresponding work for a strong acid by the difference of the amounts of work required for ionisation in the two cases. The more strongly a substance or its ions cling to the solvent, the greater in general is the degree of ionisation. The rotation of the plane of polarisation, the absorption of light, and the acceleration of reaction velocities are also closely connected with cohesion pressures. The product of the co-volume and cohesion pressure is proportional to the absolute temperature and =RT. Molecular volumes and molecular solution volumes for substances which lower the surface tension of water are approximately proportional to the square root of the cohesion pressures, as also are (1) the molecular refractions of substances with small cohesion pressures, and (2) the sum of the valencies of all the atoms in an organic compound. The relations between cohesion pressure and compressibility, plasmolysis, freezing-point, internal friction, and heats of solution and dilution are also discussed. The theory of electrolytic dissociation suffers from a fundamental error, since it takes no account of the cohesion pressure, which, like the number of particles, may increase the osmotic energy. T. H. P.

739. *Dissociation of Sodium Bicarbonate.* **Soury.** (Comptes Rendus, 147. pp. 1296–1299, Dec. 14, 1908.)—In the decomposition of sodium bicarbonate there are three constituents, so that four phases are necessary in order that fixed pressures may be obtained. The author heated at 100° a mixture of 27·54 gm. of dry sodium bicarbonate and 5·4 gm. of water, complete conversion of which into carbonate should yield 3·66 litres of CO_2. Increasing quantities of CO_2 were then removed, the corresponding final pressure being measured in each case. The pressure diminished, but two periods of fixed pressure were observed, corresponding with removal of 260–1,760 c.cm. and 2,560–3,210 c.cm. of CO_2 respectively. The first period of fixed pressure disappears when the proportion of CO_2 removed corresponds with the complete transformation of bicarbonate into the carbonate, $3Na_2O, 4CO_2, 5H_2O$, which hence forms the second solid phase. With dissociation of this carbonate in presence of neutral monohydrated carbonate corresponds the second period of fixed pressure. T. H. P.

740. *Influence of Ionic Reaction Velocity upon the Form of Potential-current Curve.* **A. Eucken.** (Zeitschr. Phys. Chem. 64. 5. pp. 562–580, Nov. 10, 1908. Physikal.-Chem. Inst., Berlin, July, 1908.)—The potential-current curve for depolarisation by $[AgCy_2]$ was calculated. The phenomenon usually ascribed to a finite reaction velocity was shown to be due to the influence of by-products upon the reaction. A finite reaction velocity demands that the smaller the reaction velocity the smaller is the intensity of the limiting curent. The calculation of the potential-current curves was shown to be correct by experiments with $KAgCy_2$. The velocity of dissociation has not previously been measured; the lower limit of the velocity of dissociation of the $[AgCy_2]$ ions was calculated ($K = 7·5 \times 10^{30}$). The reaction velocity of different anions of potassium copper cyanide was experimentally determined. The dissociation velocity for certain organic acids was calculated from previous measurements. F. J. B.

741. *Potential of the Ferro-Ferricyanide Electrode.* **G. N. Lewis** and **L. W. Sargent.** (Amer. Chem. Soc., Journ. 31. pp. 355–368, March, 1909. Contribution from the Research Lab. of the Mass. Inst. of Technology, No. 38.)—The potentials of solutions containing both ferro- and ferri-cyanide of potassium and also potassium chloride were measured; in all cases the concentrations of ferro- and ferri-cyanide were small compared with that of the potassium chloride. The electrodes used consisted of gold-plated Pt.

Immediately after being set up the electrode gave its true potential, which remained constant to within a few hundredths of a millivolt for an hour or more. The temperature-coefficient of the e.m.f. was measured at two different concentrations and the heat of the reaction in the cell determined. The results show that the heats of ionisation of potassium ferro- and ferri-cyanide are very small. The rule that in a mixture of salts having a common ion the degree of dissociation depends solely upon the concentration of that ion, was found to be accurate within one-half per cent. The presence of other anions does not influence the potential. In the presence of 0·8-*n*KCl the degree of ionisation of potassium ferrocyanide into its quadrivalent ion is not more than 2–8 per cent. This fact can only be reconciled with the measurements of the electrical conductivity by the assumption of intermediate ions. At the end of the paper is a note on the calomel electrode. It is pointed out that if a number of electrodes are made from the same materials they agree to within 0·1–0·2 millivolts, but with different samples of calomel and potassium chloride, all of a high degree of purity, more widely deviating results may be obtained. Instructions are then given for the purification of the materials, and also as to the best method of making the electrode. T. S. P.

742. *Electromotive Behaviour of Uranyl-Urano-mixtures.* **R. Luther** and **A. C. Michie.** (Zeitschr. Elektrochem. 14. pp. 826–829, Dec. 18, 1908.)—In acid solutions uranous salts are strong reducing agents. The rate of oxidation of solutions of uranous salts by oxygen of the air is greatly accelerated by platinum black, iron salts, and especially by copper salts. In the presence of acid, solutions containing a mixture of uranous and uranyl sulphate show a potential which is in agreement with the formula—

$$\epsilon = \epsilon_0 + \frac{RT}{2F} \log_e (UO_2^{\cdot\cdot})(H^{\cdot})^4/(U^{\cdot\cdot\cdot\cdot}).$$

The value of ϵ_0 is 0·419 volt more positive than Nernst's zero potential and 0·696 volt more positive than that of Ostwald. In sulphuric acid which is not too dilute, mercurous sulphate electrodes show an e.m.f. which is only slightly affected by the concentration of the sulphuric acid; this is in complete agreement with the theory of the dissociation of sulphuric acid in two stages. [See Abstract No. 1502 (1905).] T. S. P.

743. *Potentials between Liquids.* **G. N. Lewis** and **L. W. Sargent.** (Amer. Chem. Soc., Journ. 31. pp. 363–367, March, 1909. Contribution from the Research Lab. of the Mass. Inst. of Technology, No. 34.)—In the case of the potential existing between two contiguous solutions it is shown that if the ions are univalent and one ion is common to both solutions, the relation $E = (RT/F) \log_e (\lambda_1/\lambda_2)$ holds, where E is the e.m.f. and $\lambda_1\lambda_2$ is the ratio of the equivalent conductivities at the given concentrations. The potentials between six pairs of liquids were determined at 25° C., and were found to agree with the calculated values to within 0–0·3 millivolt. The pairs of liquids were: 0·2-*n* KCl—0·2-*n* K acetate; 0·1-*n* KCl—0·1-*n* K acetate; 0·2-*n* KCl—0·2-*n* KOH; 0·1-*n* KCl—0·1-*n* KOH; 0·2-*n* KCl—0·2-*n* KBr; 0·2-*n* NaCl—0·2-*n* NaOH; 0·1-*n* KCl—0·1-*n* HCl. T. S. P.

744. *Calculation of Electromotive Forces from Thermal Data.* **W. Nernst.** (Preuss. Akad. Wiss. Berlin, Sitz. Ber. 8. pp. 247–267, 1909.)—The author discusses the application of a new theorem, developed by him in 1906 [see

Preuss. Akad. Wiss. Berlin, Sitz. Ber. Dec. 20, 1906; Abstract No. 1141 (1906)], to the calculation of e.m.f.'s from thermal data. The theorem only holds if the galvanic cell is built up from pure substances, which should be either in the solid or liquid state. It is shown that in order to calculate the e.m.f. of a given combination from the heat of reaction, it is necessary to calculate the value of the thermal data at as low temperatures as possible by extrapolation from the results obtained at ordinary temperatures, use being made of the first Law of Thermodynamics. The value so obtained is then transformed to volts by using the relation $E = Q/23046$, where Q is the heat of reaction and E is the e.m.f.; the corresponding value at the desired temperature may then be obtained, either by making use of the second Law of Thermodynamics, or more simply by means of the new theorem. In the case of gas cells, the calculation can be carried out by first considering the temperature to be so low that the gases are either in the liquid or solid state, and then applying the new theorem. Then, since the solids or liquids must be in equilibrium with their vapours, the calculation can be extended, by means of the second Law, to any temperature or pressure. Details of the calculation cannot be given in an abstract, but the following table shows the agreement between calculation and experiment :—

Chemical Process.	T.	E (obs.).	E (calc.).
$Pb + 2AgCl = 2Ag + PbCl_2$	290°	0·4891	0·4890
$Hg + AgCl = HgCl + Ag$	288	0·0439	0·0437
$Zn + Hg_2SO_4 + 7H_2O(ice) = ZnSO_4 7H_2O + 2Hg$ ...	291	1·4624	1·4592
$Pb + I_2 = PbI_2$	291	0·863	0·863
$2Ag + I_2 = 2AgI$	291	0·678	0·618
$H_2 + HgO = Hg + H_2O$	273	0·934	0·880
$2Ag + Cl_2 = 2AgCl$	290	1·157	1·092
$Pb + Cl_2 = PbCl_2$	290	1·612	1·594
$2H_2 + O_2 = 2H_2O$	290	1·231	1·243
$H_2 + Cl_2 = 2HCl$ (6-normal)	303	1·160	1·170
$H_2 + Cl_2 = 2HCl$ (normal)	298	1·366	1·365

Only in three cases do the differences between the observed and calculated values amount to several centivolts. T. S. P.

745. *The Oxide Theory of the Oxygen Electrode.* Part II. **R. Lorenz** and **E. Lauber.** (Zeitschr. Elektrochem. 15. pp. 157–161, March 15, 1909. From the Laborat. f. phys. Chemie u. Elektrochemie des Eidgen. Polytechnikums, Zürich.)—The authors further study the polarisation discharge curves at lead anodes prepared in a variety of ways [see Abstract No. 175 (1909)]. They compare the results obtained with the potential measurements carried out by Streintz, and show that the arrest-points on their curves correspond with definite potentials of well-defined compounds. The number of these is considerable. In the ordinary method of discharging a lead accumulator at constant current strength, these different halting-points become obliterated, and the usual curve obtained is really due to several reactions occurring at the anode during discharge. A. F.

746. *Discharge Potentials of the Ions in Solutions of Alkali Alkyloxides.* **G. Carrara** and **A. Bringhenti.** (Gazzetta Chim. Ital. 38. 1. pp. 698–708,

1908.)—The anode potential curves of solutions of sodium methoxide in methyl alcohol and of sodium ethoxide in ethyl alcohol exhibit characteristic points at 0·82–0·84 volt, referred to the potential of the N/10 calomel electrode as zero. These values, which differ so little in the two cases that they cannot be differentiated, represent the discharge potentials of the ions (OMe) and (OEt). Similar close agreement exists between the heats of formation of the corresponding sodium salts, and it is probable that the tensions of electrolytic decomposition of these salts are also nearly equal in value. Another less sharply marked point is shown by the anode potential curves between 0·60 and 0·65 volt; it is possible that this corresponds with the discharge potential of anions of small quantities of aldehydes or acids formed by the oxidising action of the platinised Pt in presence of air. The corresponding kathode potential curves exhibit a common characteristic point at 1·22 volts, which represents that of the sodium ion. T. H. P.

747. *Electrolysis of Solutions of Selenious Acid.* I. **C. Manuelli** and **G. Lazzarini.** (Gazzetta Chim. Ital. 39. 1. pp. 50–69, 1909.)—When solutions of selenious acid are electrolysed, the acid undergoes simultaneous reduction to selenium and oxidation to selenic acid: $H_2SeO_3 + 2H_2 = 3H_2O + Se$ and $2H_2SeO_3 + 2O = 2H_2SeO_4$. Selenic acid may be conveniently prepared in this way, since the electrolysis gives rise neither to intermediate reduction products nor to complex acids, as is the case when sulphurous acid is electrolysed. The authors have studied the influence of the conditions of electrolysis on the yields of selenium and selenic acid; theoretically, 0·7388 gm. of Se should be separated at the kathode per amp.-hour, whilst at the anode a quantity of selenious acid corresponding with 1·4776 gm. of Se should be oxidised. The results show that diminution of the concentration of selenious acid and increase of the concentration of selenic acid are accompanied by a fall in the current yield of both Se and selenic acid. When a large anode and consequently a small anodic current density is employed, the yield of the oxidation product is large, whilst with a large kathode a high yield of Se is obtained. The diminished yield of selenic acid obtained when the quantity of this acid increases is not due to the establishment of an equilibrium between the oxidation of the selenious acid and the reduction of the selenic acid, since in the electrolysis of the latter, only a small amount of reduction occurs. The yields at 54–58° are not markedly different from those at 25°.

T. H. P.

748. *Supertension and Viscosity.* **C. Marie.** (Comptes Rendus, 147. pp. 1400–1402, Dec. 21, 1908.)—In order to ascertain whether the viscosity of the liquid has any influence on the p.d. necessary for the evolution of hydrogen bubbles from dilute acid, the author has made experiments with kathodes of platinised Pt, of Ni, and Pb, and dilute acid to which gum or gelatine (1 per cent.) was added. It was found that the p.d. at these kathodes increases, the increase growing with the supertension at the kathode, and being greatest in the case of Pb, and scarcely appreciable with platinised Pt. Since the anode is not changed, these effects are ascribed to the kathode, this conclusion being confirmed by measurements of the kathode potential. These results explain the beneficial action of the addition of small quantities of gelatine to electrolytes in industrial processes. T. H. P.

749. ***Electrochemical Reactions induced by Sulphur Ions.*** **M. G. Levi** and **E. Migliorini.** (Gazzetta Chim. Ital. 39. 1. pp. 110–120, 1909.)—As sodium thiosulphate may be formed electrolytically by the action of sulphur ions migrating and discharging themselves on sodium sulphite, the authors have made experiments to see whether other thio-salts and thio-organic acids are formed in this way. With sodium arsenate appreciable quantities of the thio-arsenate are formed, but with sodium antimonate and molybdate no thio-salt is obtained; in all cases, most of the S''-ions undergo oxidation to SO_4''. With formic and acetic acids no thio-acid is formed, but H_2S is always formed in the anode chamber containing the organic acid; the same phenomenon is observed when dilute sulphuric acid is used as anodic liquid. This H_2S is formed electrochemically, and is not due to the direct action of the acid on the sulphide, since experiment shows that such action will not take place through the Puckall diaphragms employed in the time occupied by the electrolysis. The amount of H_2S formed is proportional to the quantity of electricity passing if the current is low, but diminishes relatively when higher currents are used. T. H. P.

750. *Electromotive Force of Nickel and the Effect of Occluded Hydrogen.* **E. P. Schoch.** (Amer. Chem. Journ. 41. pp. 208–231, March, 1909. Contribution from the Chem. Lab. of the Univ. of Texas.)—Nickel electrodes may show widely different potentials, depending on their preparation, previous exposure to the air, &c. Thus, Ni that has been lying in air will show in N/1 nickel sulphate solutions potentials ranging from 0·25–0·32 volt. Electrodes that have been prepared by boiling in NaOH solution and then dipping in concentrated HCl showed 0·875 volt in the same electrolyte. Polarised anodically or kathodically in any liquid and then transferred to N/1 nickel sulphate solution, Ni electrodes will show almost any potential between 0·88 and zero, or even lower. However, when Ni is allowed to remain in nickel sulphate solution free from air it attains a potential between 0·43 and 0·50 volt, irrespective of the potential which it showed just before. In N/1 sulphuric acid and in dilute HCl, in both of which it dissolves slowly, Ni gives a potential of approximately 0·40 volt. At temperatures from 70–100° C. the metal attains approximately the same potential as at ordinary temperatures. At high temperatures Ni will attain this final potential very rapidly, while at ordinary temperatures more time is required. These experiments indicate that the reversible potential of Ni is between 0·45 and 0·50 volt, and the accurate determination in "neutral" N/1 nickel sulphate solution gave the value as 0·48 volt. This is a true reversible potential, because it is attained from both sides as the final point of equilibrium. Occluded hydrogen raises the potential of the Ni. The deposition of the metal does not take place except at potentials 0·2 to 0·3 volt above 0·48 volt, because hydrogen is co-deposited and, in general, deposition cannot take place until the potential of the particles to be deposited is reached. The author does not believe in the idea of a "deposition resistance" as advanced by Küster and Foerster, but is of the opinion that special potential relations exist between a deposit and the solution, this opinion being supported by the work done on Ni-Zn alloys [see Abstracts Nos. 930 (1907), 192 (1908)].

T. S. P.

751. *Electrolysis of Copper Solutions.* **J. Meyer.** (Zeitschr. Elektrochem. 15. pp. 12–20, Jan. 1, and pp. 65–78, Feb. 1, 1909. From the Electrochem. Lab. de l'École des Mines du Hainant in Mons, Belgium.)—The author is chiefly concerned with combating the theory of Foerster, Seidel, Abel, and others respecting the phenomena which occur during the electrolysis of solutions of copper sulphate. According to this theory the quantity of Cu_2O deposited from a warm solution at the kathode at a potential less than the decomposition potential of copper should be in accordance with the expression $1Cu_2O = 2 \times 96540$ coulombs, whereas the author finds that the amount is much less than this, and in some cases may conform to $1Cu_2O = 4 \times 96540$ coulombs. The formation of cuprous oxide is considered to be a purely chemical reaction and independent of the current, as also of the concentration of the cuprous ions, taking place according to the reversible equation—

$$Cu + CuSO_4 + H_2O \rightleftharpoons Cu_2O + H_2SO_4.$$

The solvent action of copper sulphate solution on Cu would thus increase with the concentration of the former, and this would explain Abel's observation that the results obtained with a copper voltameter become more trustworthy as the concentration of the electrolyte is decreased. The author also finds that it is possible to obtain a deposit of copper from acid and warm solutions of copper sulphate, using a potential less than the deposition potential of Cu, and excluding all air. Consequently Bose's phenomenon cannot be exclusively a consequence of the partial discharge of Cupri-ions, according to Abel's equation $Cu^{\cdot\cdot} + \ominus = Cu^{\cdot}$. **F. Foerster.** (Ibid. pp. 78–76, Feb. 1, 1909.)—Foerster criticises adversely the results given by **Meyer.** Among other things it is pointed out that Meyer's equation for the formation of Cu_2O is obtained by the summation of the two equations given by **Foerster,** viz. :—

$$Cu + CuSO_4 \rightleftharpoons Cu_2SO_4 \,;\; Cu_2SO_4 + O_2H \rightleftharpoons Cu_2O + H_2SO_4,$$

i.e., the relation between the two views is similar to that obtaining between the theories held as to the primary and secondary electrolytic decomposition of water. Finally, it is stated that Meyer's results do not affect the ordinarily accepted theory of the electrolysis of solutions of copper sulphate.

T. S. P.

752. *Behaviour of Nickel Anodes and Phenomena of Passivity.* **E. P. Schoch.** (Amer. Chem. Journ. 41. pp. 282–255, March, 1909. Contribution from the Chem. Lab. of the Univ. of Texas.)—The author has investigated the relation between current density and the potential of a nickel anode in various electrolytes. The electrolytes consisted of : N/1 nickel sulphate, N/1 nickel chloride, N/1 nickel sulphate acidified with (*a*) N/100 sulphuric acid, (*b*) N/10 sulphuric acid, N/1 nickel chloride acidified with N/10 hydrochloric acid ; N/1 potassium sulphate, N/1 potassium sulphate + N/10 potash, N/10 potash. For details of the results with each electrolyte the original paper should be consulted, but the following may be especially referred to : With the N/1 nickel sulphate electrolyte (at 25° C.) there is neither a critical voltage nor a critical current density which terminate the active, and mark the beginning of the passive state ; even a very small current density produces steadily lower potentials until finally the evolution of oxygen begins. Satisfactory reproducible results can only be obtained when the current densities employed form an increasing series of values, and the time of operation of any one current density is from ½ to 2 min. During the electrolysis the surface of the Ni electrode becomes impaired, *i.e.*, it will stand less current density than before at the same potential. With nickel chloride solution the results are approximately reproducible, the behaviour of the anode being essentially different from that in sulphate solutions, except at the highest potentials. At temperatures above 95° C. the anode gives normal results, both in sulphate and chloride electrolytes. The conclusions drawn from a comparison of the results obtained with different electrolytes are: (1) The extent of the "impairing effect" wrought by larger current densities upon the anode surface is roughly proportional to the concentration of the hydroxyl ions in the electrolyte. (2) The impairing of the surface in neutral and alkaline solutions may be effected as gradually as may be wished, and this process, as well as the change in potential, is perfectly continuous up to the potential at which oxygen is evolved. (3) The return to high potentials takes place at a rate roughly proportional to the concentration of the hydrions in the electrolyte. During these electrolytic actions there was no noticeable oxide film formed on the anode. The concluding part of the paper is occupied with a discussion of the results in the light of the various theories of the passive state. Evidence is adduced in support of the statement that Ni has a very small ionisation velocity. Most anodic current-densities are in excess of the ionisation velocity, and hence result in the deposition of oxygen, and the author favours the theory that a film of oxygen on the anode causes passivity. A nickel anode covered with oxygen shows lower potentials than 0·48 volt.

T. S. P.

753. *Passive State in Acid Solution.* II. **J. Alvares.** (Zeitschr. Elektrochem. 15. pp. 142–144, March 1, 1909.)—In continuation of previous work [see Abstract No. 182 (1909)] the passivities of iron and chromium in sulphuric acid solution have been studied. The method used was to observe the relation between the current and voltage across the electrodes, and thus find the position at which there was a sudden increase in potential, denoting that the anode had become passive. The current passing at this point is said to have a "critical current strength." The results obtained with iron are as follows: In sulphuric acid solutions, varying in strength from 0·087 to 5-normal, the critical current strength has a higher value when the anode is rotated than when it is stationary. It is also higher when the circuit is made after the anode has been immersed in the electrolyte than when the circuit is made by immersing the anode. In the former case the hydrogen which is formed at the anode by the action of the acid before the circuit is closed hinders the iron becoming passive. The curve showing the relation between critical current strength and concentration of the acid shows a maximum, which does not coincide with the max. concentration of the hydrions. If chloridions are added to the sulphuric acid there is no appreciable alteration in the critical current strength, as is the case with Ni, but pulsations are observed, the anode becoming alternately passive and active. Rise in temperature decreases the tendency of the Fe to become passive. So long as the anode is active it is covered with a black deposit, but immediately it becomes passive its surface appears metallic. In the case of Cr it is found that the critical current strength continually decreases with increasing dilution of the acid, both sulphuric and hydrochloric acids being used; with the latter acid the critical current strength is greater than with the former. The values in sulphuric acid are much smaller than with iron, *i.e.*, Cr is more readily made passive than Fe; it can readily be made passive in HCl of such a strength that Fe and Ni always remain active. The results show that the passive state is attained when the polarising current, *i.e.*, the velocity with which the anions are discharged, exceeds a definite value, which is conditioned by the temperature and acid concentration. In these cases the supposition that a layer of some higher oxide is formed on the passive metal is altogether untenable.

T. S. P.

754. *Electrolytic Iron.* **A. Müller.** (Metallurgie, 6. pp. 145–159, March 8, 1909. Communication from the Eisenhüttenmänn. Inst. d. Kgl. techn. Hochschule, Aachen.)—The author's experiments lead to the following conclusions: In order to keep the carbon content of the product low the (iron) anodes should be as pure as possible, and used in porous clay cells, which should be emptied and refilled with fresh solution daily. The anodes should be frequently freed from deposit by brushing with dilute HCl. Electrolyte and electrodes should be at rest. The cell should be protected with a coat of paraffin, the current density low, the kathodes carefully freed from grease, and the electrolyte free from carbon. For the complete removal of sulphur by electrolytic refining the anodes should be low in sulphur, and used in porous clay cells. The electrolyte should be $FeCl_2$, and the contents of the cells should be freed daily from dissolved sulphur by treatment with barium chloride. From 0·018 to 0·112 per cent. of hydrogen was found in ten samples of electrolytic iron. The following are nitrogen percentages in electrolytic iron prepared from ferrous-ammonium sulphate as electrolyte: 0·016 to 0·085; with ferrous chloride as electrolyte, 0·010 to 0·018. The examples of yield given show that with electrolyte of 10 to 25 per cent. concentration the yield falls below 90 per cent. if the current density exceeds about 1, and is as high as 98 per cent. with current density 0·28. With 75 per cent. concentration and 2 amps. the yield is 97 per cent. A metallographic study shows that small gas inclusions are not the sole cause of unsoundness, but that deposits (mud) are also to be seen in small quantities. A number of critical points, the highest of which is at 1,210° C., were recorded; these become less marked or vanish on repeated heating. Ar_3 occurs at 894° and Ac_3 at 917°; both points are well marked. The average value of Ar_2 is 766–759°, and of Ac_2 765–774°. Solidification extends over the range 1,505° to 1,485°. F. R.

755. *Electrolytic Deposition of Nickel.* **A. Schumann.** (Elektrochem. Zeitschr. 15. pp. 249–251, Feb., and pp. 273–274, March, 1909.)—Nickel may be quantitatively deposited from strongly ammoniacal solutions of either the sulphate, chloride or nitrate. Low-current densities should be employed and the conductivity of the electrolyte increased by the addition of ammonium sulphate. The presence of oxalates or citrates is a disadvantage. The experiments were carried out with stationary electrodes, the kathode being (*a*) a Pt dish, (*b*) a cylinder of Pt-wire gauze, (*c*) a Pt cone. T. S. P.

756. *Apparatus used in Rapid Methods of Electro-analysis. Analysis of Brass.* **T. S. Price** and **T. C. Humphreys.** (Soc. Chem. Ind., Journ. 28. pp. 117–123; Discussion, pp. 123–124, Feb. 15, 1909. Paper read before the Birmingham Section.)—The authors review exhaustively the work done by former workers by means of (1) rotating anodes, (2) rotating kathodes, and (3) stirred electrolytes with stationary electrodes. The method for determining Cu and Zn in brass, evolved by the authors is then fully described. They did not employ the method of graded potential, but the one ordinarily used in most standard separations. These may be defined as constant-current separations, even though the current may not be kept absolutely constant. Nitric acid only in the electrolyte gave unreliable results for copper, whereas the addition of H_2SO_4 in certain proportion proved satisfactory in the case of rotating electrodes. The fractional electrolysis of brass for the determination of zinc and copper is then fully described, using a modified separating funnel

as containing vessel and revolving electrodes. Two methods are given, illustrated by tables of results. Other metals, such as Pb, Fe, and Sn, are determined by ordinary methods. In the *discussion* which followed several of the speakers gave preference to the customary methods of determining copper by means of stationary electrodes, which can be performed overnight. Another speaker mentioned the fact that at the Tennessee Copper Co. in the U.S.A. both stationary and rotating methods were used, the former for accounting work and works control, and the latter for rapid determination of copper in the matte, in order to see how the furnace was running. O. J. S.

757. *Rapid Electro-analysis with Stationary Electrodes.* **J. T. Stoddard.** (Amer. Chem. Soc., Journ. 31. pp. 885–890, March, 1909.)—The experiments described in this paper show that the rotation of electrodes is not necessary in rapid electro-analysis; analysis can be rapidly carried out with stationary electrodes and no agitation of the electrolyte beyond that produced by the heating effects and gas evolution caused by the strong currents employed. In the first set of experiments a cylindrical gauze kathode surrounding a cylindrical foil anode was used, whereas in the second set a mercury kathode was employed. Good results were obtained with cadmium (nitrate + potassium cyanide), copper (sulphate + nitric acid), silver (nitrate + potassium cyanide), nickel (sulphate + ammonia), zinc (sulphate + sodium hydroxide + potassium cyanide); the times necessary for the deposition of 0·25–0·5 gm. varied from a few min. up to 30 min. [In no case does the author give the weight of metal taken and the weight of metal found, so that the accuracy of the experiments cannot be ascertained from his results.] T. S. P.

REFERENCES.

758. *On Scandium.* **W. Crookes.** (Roy. Soc., Phil. Trans. Ser. A. 209. pp. 15–46, Nov. 4, 1908.)—The original should be referred to for the information given which is mainly chemical.

759. *Overheating Phenomenon of Aluminium.* **F. Fichter.** (Zeitschr. Elektrochem. 15. p. 122, Feb. 15, 1909.)—Referring to v. Bolton's experiment described in Abstract No. 158 (1909), the author points out that a full description by C. Margot of this experiment is to be found in "La Nature," p. 181, 1895.

760. *Use of Differential Galvanometer.* **A. Portevin.** (Soc. d'Encouragement, Rev. de Métallurgie, Mém. 5. p. 295, 1908. Metallurgie, 6. pp. 101–103, Feb., 1909.)—Discusses the differential cooling curve method, and describes the apparatus used. For slow cooling of a tube resistance furnace a liquid resistance in series with the furnace is gradually increased by syphoning off the solution. F. R.

761. *Extension to Colloids of the Notion of Solubility.* **Duclaux.** (Comptes Rendus, 148. pp. 295–297, Feb. 1, 1909.)

762. *Cryoscopy of Colloids.* **J. Duclaux.** (Comptes Rendus, 148. pp. 714–716, March 15, 1909.)

763. *Dissociation of a Compound in Equilibrium.* **R. Ruer.** (Zeitschr. Phys. Chem. 64. 3. pp. 357–378, Sept. 15, 1908. Inst. f. physikal. Chemie, Göttingen.)—The paper is not suitable for abstraction and the original pages must be consulted for details. F. J. B.